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ABSTRACT

This publication is a collection of science activities designed to enrich elementary or junior high science curricula. These activities encourage students to investigate facets of life sciences, physical sciences, and earth sciences either with a teacher or independently. The 70 activities have been classified into 10 subareas under these three broad areas of science. Activities are of two basic types: constructing something, or investigating a topic and interacting with materials and resources about it. While activities were designed for independent work, many of them could be adapted to small or class-sized groups. Some activities could well be adapted to high school. The following list of selected activity titles is included: Insect Architecture; Plants Without Soil; Man: His/Her Own Worst Enemy; Hand-Me-Down Genes; Keeping your Balance; Here Comes the Sun; The "O" Zone; It's In the Stars; Living in Space; and Building a Robot that Learns. (MR)

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CHALLENGES IN SCIENCE

ACCELERATED AND
ENRICHMENT
ACTIVITIES FOR
ELEMENTARY AND
MIDDLE SCHOOL STUDENTS

SE 023288

CHALLENGES IN SCIENCE

by

Greg Staples, Beth Roth and Juanita Sorenson

TO THE USER

The activities on these cards are designed to challenge students. They are appropriate for (1) students working beyond the subject matter being studied in science class; (2) enrichment activities at approximately the same level as class materials; or (3) outside activities not necessarily related to the materials being studied.

The format of the cards allows students to select an activity or activities independently or cooperatively with a teacher. The 70 activities have been classified into 10 subareas under the three broad areas of science as follows:

LIFE SCIENCES

Animals
Plants
Ecology
Physiology

PHYSICAL SCIENCES

Matter
Energy

EARTH SCIENCES

Geology/Geography
Atmosphere/Weather
Astronomy
Space

In addition, a "general" subarea usually relating science and math is included. There are at least five activities in each of the subareas.

Activities are of two basic types -- constructing something or investigating a topic and interacting with materials and resources about it. While activities were designed for independent work, many of them could be adapted to small or class-sized groups.

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University of Wisconsin-Eau Claire
Eau Claire, Wisconsin
September, 1977

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This product was developed as part of the ongoing preservice and inservice teacher education program in the Department of Elementary Education at the University of Wisconsin-Eau Claire.

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IT'S FOR THE BIRDS

The flight of birds has been a mystery to man for hundreds of years. How has the bird developed this "talent" when man cannot? How has the body of the bird adapted for flight? Why do certain species of birds remain flightless?

01

MATERIALS

Access to reference materials and a world map.

PROCEDURES

1. Go to your IMC or library to investigate the structural modifications of the bird which allow for flight. How are the skeleton and muscles of the bird modified for flight? How do the feathers aid in flight? Investigate the importance of the wing shape in relation to flight.
2. Investigate theories on the evolution of the bird. List some characteristics of ancient birds. How did they differ from modern day birds? From these characteristics, can you tell how the behavior of ancient birds would have differed from our modern birds? What type of habitat did the first birds probably live in? What physical changes have taken place during the evolution of the bird? Why do you think these changes have taken place?
3. Find information on flightless birds. On a world map, plot the location of as many flightless birds as you can find. Do you see any pattern in the location of these birds? Explain. List some possible reasons for the evolution of flightless birds. What adaptations have been made by flightless birds? Why do you think there are so few remaining species of flightless birds? (Hint: How is man involved?)
4. Compare the structure of birds to that of our early airplanes. How is the flight of the bird like that of an airplane?

EXTENSIONS

1. Investigate the flight patterns of the hummingbird, the "helicopter" of the bird world.
2. Investigate the unusual flight patterns of the gull and the albatross.

IT'S FOR THE BIRDS

REFERENCES/HINTS

1. Clement, Roland C. The Living World of Audubon. New York: Grossett & Dunlap, Publishers, 1974.
2. Disney's Wonderful World of Knowledge. The Danbury Press, a division of Frolier Enterprises, Vol. 6, 1973.
3. Perrins, Christopher. Birds. New York: Harry N. Abrams, Inc., 1976.
4. Student Encyclopedia. Rand McNally & Co., Chicago, 1972.

Observing the development of a chick embryo can be a fascinating learning experience. It is easy to set up this activity which will help you to gain a better understanding of not only the development of the chick, but also of your own development.

02

MATERIALS

Approximately 12 fertilized chicken eggs (you can vary this number), 1 unfertilized chicken egg, an incubator, 6 small jars, enough formaldehyde to fill the jars (ethyl alcohol will also work), gram scale, and small amounts of milk and oatmeal.

PROCEDURES

1. Open one of the fertilized eggs and one unfertilized egg. How do the two eggs compare? Where is the germ cell of the fertilized egg located? Explain what will happen to the germ cell when the fertilized egg is placed in the incubator.
2. Research to find the necessary information for hatching chicken eggs in an incubator. Be sure to find out how many days before the chicks will hatch. Also be sure to keep the eggs at the correct temperature. ($99\frac{1}{2}^{\circ}$ - 100° F or 37.5° - 37.8° C) After you have all of the necessary information, place the eggs in the incubator and begin!
3. Open one of the chicken eggs every third day. Place the specimens in jars of formaldehyde (alcohol will also do). Make a sketch of the embryo at each stage of development. Be sure to label each sketch, and describe the changes which have taken place since the last stage. Compare the development of the chick to the development of a human. How are they similar? Different?
4. After the remaining eggs have hatched, record the weight of each chick on a chart. (You might want to put a small colored spot on the head of each chick in order to distinguish each one.) Record the weight of each chicken each day for two weeks. (Always estimate the weight first!) Make a graph of your findings.
5. Determine if milk in the chicken's diet will make a difference in growth. Do this by feeding one chicken small amounts of milk and oatmeal. Feed the other chickens small amounts of water and oatmeal. Again, estimate and weigh the chickens each day for 2 weeks. Graph your data.

EGG-CITING

EXTENSIONS

1. Report your information to the other members in your class.
2. Visit a commercial chicken breeding business and find out how they raise chickens.

REFERENCES/HINTS

1. Moseman, Mildred. "Hatching Chicks." Science and Children, Vol. 13:1, p. 22.
2. World Book Encyclopedia. Chicago: Field Enterprises Educational Corporation, Vol. 2 (Bird, p. 272), 1977.
3. World Book Encyclopedia. Chicago: Field Enterprises Educational Corporation, Vol. 10 (Incubator, p. 89), 1977.

A horse is a horse, of course? Of course! But the ordinary horse wasn't always ordinary. Thousands of years ago, the horse appeared much different than it does today. Let's look for the "roots" of the modern horse.

03

MATERIALS

Access to reference materials.

PROCEDURES

1. Trace the evolution of the horse from the small, terrier-sized Hyracotherium (also known as Eohippus, the "dawn horse") to the large modern horse, Equus. How far back in time can you trace the ancestry of the modern horse?
2. Describe the characteristics of the Hyracotherium. How did it differ from modern-day horse? From these characteristics, can you tell how the behavior of the Hyracotherium would have differed from our modern horse? What type of habitat did the Hyracotherium probably live in? What physical changes have taken place during the evolution of the horse? How have these changes affected the behavior of the horse?
3. The modern horse arose in North America at the close of the Pliocene epoch and spread rapidly over most of the world. However, Equus (modern horse) vanished from North America a few thousand years ago, before the arrival of the first white colonists. Explain why and how this might have happened. Write a fictional story about the vanishing of horses from North America. How did the present-day horse return to North America?
4. Compare the evolution of horses to that of man. Are there any similarities? Some theories state that the horse is a relative of man. Why do you think some people believe this is true?
5. Investigate the domestication of horses. When did this event begin to take place? How have horses influenced our history?
6. Make a geneology chart showing the evolution of the modern horse. Include as many branches as you can.

A HORSE OF A DIFFERENT--SIZE?!?

EXTENSIONS

1. Research to find information on wild horses remaining in the U.S. today. What has the Federal Government done to protect these animals?
2. Investigate the occurrence of different breeds of horses. Are we still forming new breeds? How is a breed defined?

REFERENCES/HINTS

1. Moore, Ruth. Evolution. New York: Time-Life Books, 1968.
2. "The Mustang Roundup." Newsweek, September 5, 1977, p. 22.
3. Ryden, Hope. "On the Track of the West's Wild Horses." National Geographic, January 1971, p. 94.

You wouldn't mistake a dog for a cat. But can you tell one kind of dog from another? Man has developed a system to show how each kind of animal is different from another. This is the science of classification, and it is very useful. Try your hand at classifying some animals.

04

MATERIALS

Access to reference materials and an opportunity to visit a zoo with a large variety of animals.

PROCEDURES

1. Investigate the common system by which man classifies animals. Who first classified living things according to this system? What are the advantages and disadvantages of such a system?
2. Complete the following classification categories for human beings:

Phylum
Class
Order
Family
Genus
Species

Complete the same categories for two other animals of your choice.

3. Most of the animals that are of great importance to man for food (cow, pigs, sheep), for companionship (pets), for labor (burro, water buffalo), and for sport (horses, fish) belong to the group called vertebrates. The five classes of vertebrates are:

Amphibians
Birds
Fish
Mammals
Reptiles

Indicate the common names of several representatives for each of the five classes listed above.

NAME THE ANIMALS

4. Take a trip to a zoo which has a variety of animals. Visit each cage or area of the zoo in a systematic fashion. Note or seek out the following information for each vertebrate animal:

Common Name

Scientific Name (Latin - Genus and species)

Class

Chief observable characteristics

EXTENSIONS

1. Take the list of characteristics you prepared for Procedure 4 and develop your own classification system. Have someone try to use it to see if it is successful.
2. Investigate Darwin's theory on evolution. How does it relate to certain species of animals becoming extinct?

REFERENCES/HINTS

1. Allen, Thomas B. Vanishing Wildlife of North America. Washington D.C.: Special Publications Division, National Geographic Society, 1974.
2. Carrington, Richard. The Mammals. New York: Time-Life Books, 1967.
3. Wise, William. The Strange World of Sea Mammals. New York: G.P. Putnam's Sons, 1973.
4. Contact with the zoo keeper or the zoo education division.

You probably think that most animals have a body framework of a bony skeleton like you'll find in a man or in a dog. But the fact is that most of the Earth's animals do not have backbones, but are supported and protected by a hard outer shell or other coating. They make an interesting group to observe and study.

05

MATERIALS

Access to reference materials, live planaria and other invertebrates.

PROCEDURES

1. Investigate the general category of invertebrates. Which groups do you already know and which ones are new to you? If invertebrates don't have backbones, what holds them together?
2. Scientists have classified invertebrates into general groups (usually called phyla). Nine of the most common groups are listed below. See if you can find the common names of animals in each group.

<u>General Group (Phyla)</u>	<u>Common Names for Animals in Group</u>
Protoza	
Porifera	
Coelenterata	
Platyhelminthes	
Nematoda	
Echinodermata	
Mollusca	
Arthropoda	
Annelida	

3. Investigate the living habits of the giant octopus. Can you write a fiction story involving man and the octopus? Is the octopus a friend or enemy of man? Why?
4. Many members of the Platyhelminthes group of invertebrates are parasites in man, especially in tropical areas. Find out what the most common parasites are and how they affect man. What measures can be taken to prevent and cure parasitic diseases?

ANIMALS WITHOUT BACKBONES

EXTENSIONS

1. Investigate the planaria and its ability to regenerate. Obtain some planarias from a biological supply house. You can get information on them from a science teacher in your system. Try some experiments with planaria and regeneration.
2. Study the life cycle of the malaria organism and the mosquito that carries it. Develop a chart to show the stages in the disease. How is malaria cured and prevented? Where is malaria usually found? Why?

REFERENCES/HINTS

1. Buchsbaum, Ralph. Animals Without Backbones. Illinois: University of Chicago Press, 1938, 1948, 1968. (This is a classic book on invertebrates.)
2. Engel, Leonard. The Sea. New York: Time-Life Books, 1969.
3. Voss, Gilbert L. "Shy Monster, the Octopus." National Geographic, Vol. 140, No. 6, December 1971, p. 776.

EARTH'S MOST NUMEROUS CREATURES

More than a million different kinds of insects have been named and identified. Insects are the most numerous living things on Earth, and they range widely in appearance and size. How have insects learned to survive and thrive in a world of larger animals? In what ways has man battled with insects to survive?

06

MATERIALS

Access to reference materials and dried insect specimens.

PROCEDURES

1. How do you identify an insect as different from all other animals? Is an insect a vertebrate or an invertebrate? Why? Where is an insect's backbone? Do all insects have wings? Explain with examples. Do all insects have legs? Explain with examples.
2. All animals and plants have been classified into a phylum, class, order, family, genus and species. The common housefly is classified as follows:

Phylum	Arthropoda
Class	Insecta
Order	Diptera
Family	Muscidae
Genus	Musca
Species	domestica

Notice that the first letter of each category is capitalized except for species.

3. Using reference books, identify the six categories listed in Procedure 2 above for the monarch butterfly, the cecropia moth or the June beetle. Why do scientists classify animals into so many categories? How are these classifications used by other scientists, farmers, etc.?
4. It's easy and fun to classify insects into orders. Ten orders that insects can be classified into are listed below. Use reference books to find which of the commonly-found insects fit into each order.

Order	Common Names of Insects in Order
Thysanura	
Odonata	
Orthoptera	
Isoptera	

EARTH'S MOST NUMEROUS CREATURES

Order	<u>Common Names of Insects in Order</u>
Heteroptera	
Homoptera	
Lepidoptera	
Diptera	
Coleoptera	
Hymenoptera	

5. Make a collection of insects from gardens, woods and meadows near your home. Classify these insects into the 10 orders listed in Procedure 4. Can you identify the major characteristics of insects in each order? Use an insect "key" which you can buy in a bookstore to help you.

EXTENSIONS

1. Research the butterflies and moths of South America and Africa. How do they differ from those of Europe and North America? Explain.
2. Raise silkworms or fruit flies and observe their life cycles. Ask a biology teacher to help you design an experiment to identify genetic differences in fruit flies from one generation to another.

REFERENCES/HINTS

1. The Insects. New York: Life-Time Series, 1967.
2. Johnson, Warren R. and Howard H. Lyon. Insects That Feed on Trees and Shrubs. Cornell University Press, 1976.
3. Sisson, Robert F. "The Wasp That Plays Cupid to a Fig." National Geographic, Vol. 138, No. 5, November 1970, p. 690.

INSECT ARCHITECTURE

Insects have been constructing elaborate shelters for themselves for hundreds of millions of years. The organization of these insects and the precise construction patterns they follow can be very interesting to investigate.

07

MATERIALS

Access to reference materials.

PROCEDURES

1. Read basic reference materials on insects and their methods of constructing homes. Compare the "architecture" of wasps, bees, and termites. Answer the questions below.
2. How does the paper wasp "manufacture" the paper used in making its nest? What substance is the paper similar to? How does the construction of the hunting wasp differ from the paper wasp? Where does the hunting wasp usually build its nest?
3. Investigate the construction methods of the "champion skyscraper builder", the termite. Where are the largest termite shelters found? About how many termites inhabit the large, rock-hard structure? Explain how the termite is able to control nest ventilation, humidity, and temperature. What vital function do termites fulfill in our forests?
4. What is unique about the structure of a bee's honeycomb? How do you think the honey bee ever stumbled upon this method of construction? Investigate the different types of nests built by some of the over 3,000 species of bees in North America.
5. Write an imaginative story about the construction patterns of honey bees. Be sure to include the jobs of the different types of bees in the caste (e.g., queen, workers, drone, nurses, etc.). Perhaps you could "become" one of the bees and include your attitude toward your job.

EXTENSIONS

1. Investigate the hobby of raising honey bees in glass beehives. Maybe you would like to get a swarm and raise bees yourself.

INSECT ARCHITECTURE

2. See if you can find a large glass case in which you could observe the building activity of ants. Compare their living and working habits to those of bees. Do they have a "caste" system?
3. Investigate the unique shelter of the Potter Wasp.

REFERENCES/HINTS

1. Disney's Wonderful World of Knowledge. The Danbury Press, a division of Grolier Enterprises, Inc., Vol. 6, 1973.
2. The Insects. New York: Life-Time Series, 1967.

Scientists have been puzzled for many years about the unusual migration patterns of the monarch butterfly. Only recently have scientists discovered their winter home. Where is this hiding place? Why do the monarchs go there?

08

MATERIALS

Access to reference materials and an outline of a map of North and Central America.

PROCEDURES

1. Investigate the recent discoveries made in relation to the wintering place of the eastern population of the monarch butterfly. What type of climate is necessary for the monarch during the winter months? Describe the activities of the migrating monarch.
2. On a large map, plot the migration routes of the eastern populations of monarch butterflies. Do you see a pattern? How would you explain the fact that monarch butterflies from the United States - and even Canada - fly across mountains, valleys, deserts, prairies, and cities to a remote "pinpoint" on the map of Mexico? Why do you think monarchs have chosen this location for their wintering grounds? List some possible signals which might trigger the northbound migration of the monarch.
3. How is the monarch butterfly able to survive during the winter migration period? How does the life span of the monarch relate to its migration pattern?
4. Investigate the entire life cycle of the monarch butterfly. Bring in eggs or pupae from the monarch butterfly and watch their complete metamorphosis.

EXTENSIONS

1. Find information on other insects that migrate. Compare the location of their winter homes to that of the migrating monarch.
2. Investigate the migration of birds and other animals.

MILLIONS OF MONARCHS

REFERENCES/HINTS

1. Uriguhart, Fred A. "Found at Last: The Monarch's Winter Home." National Geographic, Vol. 150, No. 2, August 1976, p. 161.
2. Disney's Wonderful World of Knowledge. The Danbury Press, Vol. 6, p. 104, 1973.

SOMETHING FISHY

The guppies in this experiment have gotten themselves into "hot water". See what they do when the "heat is on".

09

MATERIALS

5 one-quart jars, 5 Celsius thermometers, a package of elodea, and 2-3 guppies.

PROCEDURES

1. Fill a one quart jar about half-full of tap water and place several sprigs of elodea and the guppy in the jar. Observe the guppy carefully. How can you tell that the guppy is alive? How might you find out whether guppies are affected by the temperature of the water in which they are placed?
2. Try this procedure:
 - a. First, record the number of gill movements and the general body activity of the guppy at room temperature (20°C). Do this for a one-minute interval.
 - b. Then, using the four remaining jars, place the guppy in water baths of succeeding high temperatures. (Increase the temperature of the water in in each jar by 5°C.)

Note: Before beginning to count gill movements, wait one minute or longer until the guppy is used to the new temperature environment.

3. Record your data on a chart like the one below:

Trials	Temperature	Gill Movements per Minute	General Body Activity
1			
2			
3			
4			
5			

SOMETHING FISHY

4. Graph your data. (Put gill movements per minute on the verticle axis, and the temperature on the horizontal axis.)
5. Using your data, answer the following questions:
 - a. How does water temperature appear to affect the life processes--especially the breathing rate of the guppy? Does the rate of the gill movement increase?
 - b. How did the guppy act as the temperature of the water increased?
 - c. What finally happened to the guppy as the temperature was raised to 40°C?
NOTE: Guppies will not ordinarily survive in water temperatures above 40°C or below 20°C.

EXTENSIONS

1. Try the same procedures with a second guppy and compare the data. Now try them with a third guppy. Be sure you carry out the procedures exactly the same each time. How do the results compare? What generalization can you make about water temperature and the activity of the three guppies? Be sure you limit your conclusions to your data.
2. Changing the normal temperature of a lake or stream is called thermal pollution. Investigate this topic to find out how man affects nature's balance with thermal pollution. What are some sources of thermal pollution?

REFERENCES/HINTS

1. Esler, William K. Teaching Elementary Science. California: Wadsworth Publishing Co., 1977, p. 217-219.

Can you imagine people living without air or water? Can you imagine plants without soil? Well, believe it or not, you can actually grow plants that don't need soil to survive.

10

MATERIALS

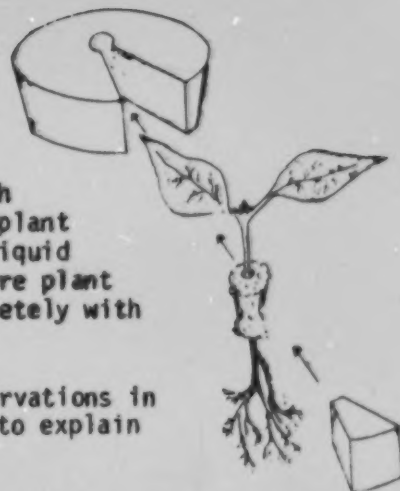
Seeds of common plants (e.g., bean, wheat, radish, tomato, sunflower, corn, rye), paper towels, short, thick wooden dowel, small container, plastic coffee cup, a one-inch-thick piece of styrofoam as wide as the cup, piece of cotton, knife, liquid, all-purpose plant food, and tap water.

PROCEDURES

1. First, you will need to germinate the seeds you are going to "plant". If you have done this before, use a procedure you are familiar with. If you've never germinated seeds, try the technique described below:
 - a. Place the seeds in a row lengthwise down the center of one paper towel.
 - b. Place a second towel on top of the seeds to form a "sandwich", and roll the sandwich around a short wooden dowel.
 - c. Place a loose-fitting rubber band or string around the entire roll to keep it from coming apart.
 - d. Place the roll upright on one end in a container holding about one inch of tap water (because water will be continually evaporating, be sure to regularly add more water).
 - e. After the seedlings grow to a length of several centimeters (2-7 days) they are ready for planting . . . but wait! We aren't going to use soil!
2. To construct the device needed to grow your "plants without soil" follow this procedure:
 - a. Remove a wedge-shaped portion of the styrofoam piece in the same manner that you might slice a piece of pie. Cut off the tip of the wedge, and enlarge the space on the lid where the wedge-tip was removed. This area will accommodate the plant stem. See diagram.

PLANTS WITHOUT SOIL

- b. Wrap cotton around the base of the young plant before securing it with the wedge as shown in the diagram.
 - c. Fill the plastic cup with the diluted "all purpose plant food" and position the plant with its roots dangling in the fluid. (NOTE: The "plant food" should be mixed with water.) Keep the liquid level full in the cups by adding water--not more plant food. Once a week, replace the solution completely with a fresh supply.
3. Check your plants every two days. Record your observations in a notebook. Which kind of plants grew best? Try to explain reasons for this.



EXTENSIONS

1. Compare and contrast the growth of your plants to plants grown in plain tap water and soil.
2. Investigate to find out where and under what conditions plants are grown by hydroponics on a commercial basis.
3. Do you see any application of hydroponics to colonization of outer space, Antarctica, or areas north of the Arctic Circle? Explain. Write a fiction story involving the role of hydroponics in such areas and its relation to the society, politics, and economics of a colony.

REFERENCES/HINTS

1. McCormack, Alan J. "Hydroponics - Plants Without Soil!" Science and Children, Vol. 10, No. 5, January-February 1973, p. 25.
2. World Book Encyclopedia. Chicago: Field Enterprises Educational Corporation, Vol. 9 (Hydroponics, p. 418), 1977.

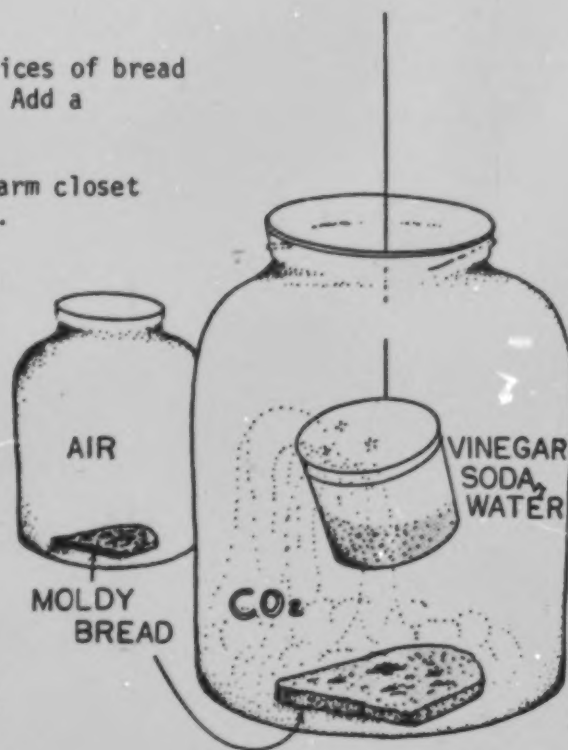
Most of the time people try to think of ways to keep mold from forming on foods and around their house. But in the experiment below you will try to find ways in which mold will grow the best.

MATERIALS

2 large jars (4-6 liters), 2 slices of bread, garden soil, water, small can, string, tape, diluted vinegar (50% water), and baking soda (bicarbonate).

PROCEDURES

1. Sprinkle some garden soil over the two slices of bread and place one in each of the large jars. Add a tablespoon of water to each jar.
2. Seal the jars and place them in a dark, warm closet until the bread in each jar becomes moldy.
3. Then, tie or tape a small can to a string and partially fill the can with the diluted vinegar. Add the baking soda to the vinegar.
4. Lower the can into one of the jars. See diagram:
What type of gas is being given off by the solution in the can? Lower the can into the SAME jar several times. Then quickly reseal the jars and place them in the closet again. Do not disturb the other jar.
5. Take the jars out of the closet each day, and compare the growth of the mold in the two jars. Record your observations in a notebook.
6. Using your data, answer the following questions:
 - a. In which jar did the mold grow faster?



MOLD: PLANT OR ANIMAL?

- b. What gas was most plentiful in the jar in which the mold grew faster?
- c. In which jar will the mold live the longest? Be careful!

EXTENSIONS

1. Perform the experiment again using radish or bean seeds instead of mold.
2. Research the relationship of mold and penicillin.

REFERENCES/HINTS

1. World Book Encyclopedia. Chicago: Field Enterprises Educational Corporation, Vol. 13 (Mold, p. 574b), 1977.

THE FIRST GREEN PLANTS

Here's a tricky question. Which is stronger--mosses or rocks? Well, in the long run, the mosses will win every time. As a matter of fact, mosses are called the "soil former" because of their ability to break down rocks and stones. Find out more about these amazing plants.

12

MATERIALS

Hand lens, microscope, slide and cover slip, tablespoon, baggies, flower pot (small with hole), large glass, saucer, paper towels, water, and access to reference materials.

PROCEDURES

1. Before actually observing moss plants, investigate this topic in your library or IMC. Use the following questions to guide your research:
 - a. Why is moss called a "soil former"?
 - b. What does moss look like? Does it have parts (stems, leaves, roots, flowers) like the plants you usually see?
 - c. What does moss need to grow? To reproduce?
 - d. Where is moss found?
 - e. How is moss useful to man?
 - f. Why do you think moss covered the land in ancient times?
2. Look on the school grounds, in your neighborhood, and in a woodsy area to find moss specimens. Bring small specimens to school. Be sure to record exactly where each specimen was found. Try to find some with stalks and capsules.
3. Examine and record observations for each moss specimen. Smell the moss. Record your findings. Determine if any of the mosses are ready to reproduce. Observe all parts under the microscope. Find and draw the following parts: capsule, stalk, leaves, stem, rhizoids.
4. Try to grow a moss plant from spores. Use this procedure:
 - a. Fill a clean, wet flowerpot with wet paper towels.
 - b. Invert the pot (upside-down) on a saucer.

THE FIRST GREEN PLANTS

- c. Scatter spores over the flat bottom of the flowerpot by tapping a capsule or fern leaf held over it.
 - d. Cover flowerpot with a drinking glass to keep the humidity inside the glass.
 - e. Spores should grow on moist surfaces. They will be about the size of a small fingernail after several weeks.
 - f. Transplant to soil after several months when plant begins to look like a miniature moss.
5. Summarize the information you have gained, and prepare a short report for the class.

EXTENSIONS

1. In resource books or museums, explore the history of mosses and ferns in prehistoric times. How is coal related to these plants?
2. Investigate the growth of ferns and compare their growth to a bean plant. Explain similarities and differences. How does each reproduce? Explain.
3. Make a trip through a park or woods in your area to see how many kinds of ferns you can find. Make a key to help others identify the different kinds of ferns. Have a friend or classmate try the key out.

REFERENCES/HINTS

1. Student Encyclopedia. Rand McNally & Co., Chicago, 1972.
2. Jensen, Amy Elizabeth. The How and Why Wonder Book of Mushrooms, Ferns, and Mosses. Charles E. Merrill Books, Inc., 1965.

APPLES OR ORANGES

What would you get if you tried to grow grapes on an apple tree? A grapple? Maybe not, but it is possible, by using a method called grafting, to grow unusual combinations of different kinds of fruit on one tree.

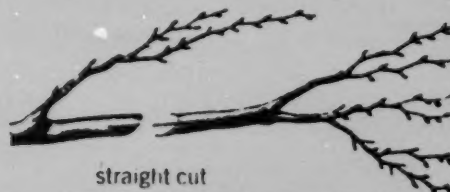
13

MATERIALS

Access to reference materials, two closely related fruit trees (e.g., apples and pears), grafting wax, and string or strips of cloth.

PROCEDURES

1. Find information on the different methods of grafting plants. Someone at a nursery or garden shop in your town would be an excellent resource person. Find out what type of plants are most often grafted. Why does man graft plants? Are new varieties created when two plants are grafted? Become familiar with the following terms: scion, stock, cambium, inarching, whip grafts, bridge grafts, and bud grafts.
2. Prepare and graft two closely related fruit trees, such as two kinds of apple, apple and pear, or orange and lemon. Follow the directions below:
 - a. Remove a branch from each tree by cutting it diagonally. Make sure the branches are about the same size. Discard the branch you cut from the tree you wish to use as the parent.
 - b. Make a straight cut in each of the two parts that are to fit together. See diagram on the right:



- c. Trim the ends so that they join in the form of a letter N when the new branch is inserted in the parent tree. See diagram on the right:



APPLES OR ORANGES

- d. Wind strips of cloth or string around the joint several times so that the grafted branch is well supported on the tree. Tie the graft tightly.
 - e. Cover the graft with grafting wax or melted paraffin to keep it from drying out.
3. What kind of fruit will your graft have? Explain why you think so. If an apple tree is grafted to a pear root, what will the leaves be? The fruit? If you were a farmer, and you discovered a seedless orange tree, how would you produce more seedless orange trees? How many seedless orange trees could you produce? Do you think it is possible to grow five kinds of apples on one tree? Explain how you would do this. Why would anyone want a tree like this?

EXTENSIONS

1. Try to graft tomatoes to potatoes. Also you should have success grafting plums to peaches.
2. Investigate the process of grafting in relation to humans. Explain how this is done.

REFERENCES/HINTS

1. Brandwein, Paul F., et al. Concepts in Science. New York: Harcourt Brace Jovanovich, 1972.
2. Contact your local county extension agent for more information on grafting.

What happens to a tree during the school year? How much does it change? Do we fail to make keen observations of trees? Follow the procedures below to improve your observing skills.

14

MATERIALS

A small notebook or diary.

PROCEDURES

1. This will be an ongoing activity for the school year. You will be surprised at all the things you will learn if you are a careful observer.
2. Be sure to title each page in your notebook with the day of the year, time of the day, and weather conditions.
3. Select a convenient tree near the school ground. What kind of tree is it? When was it planted?
4. In your notebook, write down your observations for each day. Look very carefully, especially on the first few days. How does the tree look, smell, feel? What colors do you see? Any birds or animals in the tree?
5. As the year goes on, you will have gathered a wealth of information about the tree. But you must be patient. Changes in the tree will come slowly. You will need a sharp eye to notice the differences.
6. When you are finished, be sure to review your notebook. Prepare a report for the class about your tree. Tell them the most interesting things you observed.

EXTENSIONS

1. Try writing a short story or entries in a diary where you are the tree. Be creative and explain your "feelings" on different occasions.

REFERENCES/HINTS

1. Hutchins, Ross E. This is a Tree. New York: Dodd, Mead & Company, 1964.

Did you realize that the clear, clean-looking water that you drink everyday may not be as pure as it looks? What is pure water--and how does it get that way?

15

MATERIALS

Access to reference materials, contact with resource persons in local area.

PROCEDURES

1. Investigate the different methods of water purification in use today, (e.g., coagulation and settling, filtration, disinfection). Which method do you think is most effective? Most economical? What method is used in your community? (Note: Your local water department will be able to give you the necessary information.)
2. Outline an effective plan for water purification that could be used in your community. What things would you need to know about your community? What factors must be considered when building a water purification system? What problems have to be considered in building such a plant?
3. Locate information on the U.S. Public Health Service drinking water standards. How is the government able to determine if a community is meeting the specified drinking water standards? Find information on the many materials which are found in water (e.g., arsenic, barium, boron, cadmium, cyanide, fluoride, lead, silver). Why is it necessary to limit the amount of each of these materials in our drinking water? (Note: It will be necessary to look at each material separately.)
4. Compare the standards set for drinking water to those set for water to be used for industrial purposes. Make a list of different industrial uses of water. Why do the requirements for industrial uses of water vary so widely?
5. How does rain water get "purified" so it meets health standards when it is taken from a well? Explain.
6. Work with your local Public Health Services to get a water testing kit. Test water from your faucet, a lake or river, several wells, etc. Compare the results.

CLEAR WATER

EXTENSIONS

1. Chlorine is the most commonly used chemical to purify water. In recent years many citizen groups have become concerned that chlorine is a "poison" and may harm human health in areas where it is used. Investigate this problem in your community and state. Also, contact your library to see if you can get more information on the topic.
2. What is meant by the term "hard water"? How is "hard water" changed to "soft water"?
3. Write a story comparing the life styles of people who live in areas with plenty of water compared with those who live in a desert area. Focus on how people value water in each area.

REFERENCES/HINTS

1. Thompson, Stephen. "Ozone + Ultrasonics = Purified Water." Popular Science, Vol. 206, No. 2, February 1975, p. 64.
2. World Book Encyclopedia. Chicago: Field Enterprises Educational Corporation, Vol. 21, (Water, p. 102), 1977.

Some of the common household products which we use in our home have a tremendous effect on our environment. By trying just a few experiments you may begin to see how man can affect different kinds of plants and animals.

16

MATERIALS

1 or 2 common household products (e.g., weed killer, scouring powder, liquid bleach, hair spray, house paint, window cleaner or ammonia cleaner), 1 or 2 small organisms you can study (see chart below for a list of organisms and possible effects which you could study), and containers to keep your organisms in.

Possible organisms <i>collect them yourselves, if you can</i>	Possible effects to study
algae, seaweed	growth rate, color change
leafy aquatic plants	growth rate, color change
hydra	rate at which it regrows parts
flatworms	rate at which it regrows parts
snails or periwinkles	growth rate, reproduction rate
daphnia, fairy shrimp	heartbeat rate
brine shrimps (available as eggs)	growth rate
crayfish	growth rate, breathing rate
larvae of aquatic insects, mayflies, dragonflies, mosquitos	rate of development
water striders	ability to stand on the surface
frog sperm and frog eggs	fertilization rate (number of eggs that start to hatch)
frog eggs, tadpoles	rate of development
young local fish—bluegills, sunfish, bullheads, minnows, catfish, mud minnows, top minnows	behavior, breathing rate
goldfish	breathing rate, behavior

PROCEDURES

1. Find out about the normal behavior of the organism you chose to observe. Find out how to care for it, where it lives and the kind of food it eats, if it is an animal. The library or a pet shop are good places to look for this information. Some things you will need to find out about the organism are: Should you keep your organism in deep water or shallow water? What will you feed it and how often? If it is an animal, does it need to have plants in the water?

MAN: HIS/HER OWN WORST ENEMY

2. Write out a plan for your investigation of how a household product will effect living things. Decide on how much of the household product to use. Decide on how much water you will need. You may want to test different amounts of the household product on the organisms. For example, one container could test the effects of 1 ml of the product in 200 ml of water. Another container could test 0.1 ml of the product in 200 ml of water. Also, be sure to include a control. This would be a container in which no household product was added to the water. Be sure to label each container.
3. Carry out an experiment. Observe your organisms each day for 3 weeks. (The time may vary depending upon the organism and the product used.) Record all observations. Watch for pollution effects you did not plan to test for. If it looks like the household product is seriously harming your plant or animal, stop the experiment immediately. Place the organism in clean water.
4. If possible, graph your data.
5. Answer the following questions:
 - a. Did the product you tested cause pollution?
 - b. Can the individual person effect environmental change and its rate?
 - c. How much do you and your family contribute to the water pollution problem?

EXTENSIONS

1. Repeat the experiment above using 2 or 3 different household products and 2 or 3 different organisms. Compare the results.
2. Research the topic, "Lake Erie is Dead". Is Lake Erie really dead? What are the major causes of pollution in Lake Erie?

REFERENCES/HINTS

1. Rasmussen, Frederick A., et al. Man and the Environment. Boston: Houghton Mifflin Co., 1971.
2. Young, Gordon. "Pollution, Threat to Man's Only Home." National Geographic, Vol. 138, No. 6, December 1970, p. 737.
3. Young, Gordon. "The Great Lakes: Is It Too Late?" National Geographic, August 1973, pp. 147-185.

People can live for weeks without food. People can live for a few days without water. But people can only live a few minutes without air. Find out what man is doing to the air we breathe and how to keep it pure.

17

MATERIALS

Access to reference materials, waxed paper, cardboard, small amounts of vaseline, magnifying glass, and a map of your community.

PROCEDURES

1. Become familiar with the following terms: carbon monoxide, smog, photochemical smog, fly ash, agricultural burning, emphysema, asthma, bronchitis.
2. Make a list of the main sources of air pollution and explain how they pollute the air. What is carbon monoxide? How is man affected by this poison? Find information on agricultural burning. In which states is agricultural burning most common? How many sources of air pollution can you find in your city? Plot the locations of these sources on a map of your community. Is there a specific area where air pollution is greatest in your community?
3. How would you deal with the following problems? Write a short story explaining your position.
 - a. There is a company in your town which supplies the town with a major portion of its employment, but it is polluting the air.
 - b. Cars cause 60 to 70 per cent of all air pollution in cities. How would you solve this tremendous problem? Why has it been such a hard problem to solve in Los Angeles, California?
4. Make a list of the products in your home which are packaged in plastic containers. Why is the use of plastic containers more harmful to our environment than paper or glass containers? Of the products on your list, which ones could be purchased in a paper or glass container?
5. Try the following activity which deals with identifying air pollutants:
 - a. Cut a piece of waxed paper into 6-centimeter squares. Staple each square to a heavy cardboard.

cont.

SMOG AND FOG

- b. Coat the wax paper with a thin layer of vaseline.
 - c. Place the papers in various locations around your school.
 - d. At the end of one week collect all the papers. Examine each paper with a magnifying glass to see which received the most pollution particles. Try to identify such pollutants as dust, ash, and soil. Which was the most common pollutant? In which location did you gather the most pollutants? Why do you think this was so?
 - e. Using your data, make a chart. Be sure to include date placed, date collected, location, amount of pollution, possible cause of pollution, and reasons for the different amounts.
 - f. Remember you collected only pollutant particles. There are also many pollutants which cannot be seen or collected easily.
6. List the different diseases caused by air pollution. What are the symptoms of these diseases? What preventive measures can be taken to avoid getting the diseases? Besides harming man's health, how else does air pollution affect him? In what ways does air pollution cost man money?
 7. Locate information on the methods used to combat air pollution. Which method do you think is most successful? Most economical? How does planting bushes, trees, and grass along a highway help to reduce air pollution?

EXTENSIONS

1. Investigate the 1952 Killer Smog in London, England. Find information on air pollution catastrophes in the United States and other countries.
2. Talk to an agriculture teacher from a high school or college or a County Extension Agent about the damage done to agricultural products by air pollution.

REFERENCES/HINTS

1. "The Aerosol Threat." Newsweek. October 7, 1974, p. 74.
2. Educational Research Council of America. Man and the Environment. Boston: Houghton Mifflin Co., 1971.
3. Young, Gordon. "Pollution, Threat to Man's Only Home". National Geographic, December 1970, pp. 738-781.

"Water, water everywhere, and not a drop to drink," said the ancient sailors as they went thirsty because they couldn't drink seawater. That is changing today. Man has learned how to take the salt out of sea water so deserts may bloom and dry lands support people even though there are no lakes or rivers present.

18

MATERIALS

Access to reference materials on desalinization (removing salt) of ocean or sea water.

PROCEDURES

1. How much salt is there in ocean water?
2. Why is it so difficult to separate salt from water? Explain.
3. Identify several methods for separating salt from water. Which of these seem to be the most successful?
4. Since man does know how to separate salt from sea water, why isn't it used more widely? Explain.
5. Investigate the desalinization plants at places like Key West, Florida and Freeport, Texas and many places in Israel and Saudi Arabia. How do these plants work? Again, what is the main problem with getting fresh water in this way?
6. Go to the library and get the addresses of the Westinghouse Corporation and the Fairbanks Morse Corporation. Write letters asking them to send you more information on their desalinization plants and on the processes they use.

EXTENSIONS

1. On a map of the world, identify locations where man could live and grow crops if water were available. You will have to consider suitable elevation and land forms (plains, valleys, plateaus, but not mountains). After you have identified the locations, check out your predictions with a geography book to see if you were correct.
2. Make or obtain a diagram of a desalinization plant. Write an explanation of how it works.

FRESH WATER UNLIMITED

3. Make your own desalinization equipment and distill fresh water from salt water. What happens to the salt?

REFERENCES/HINTS

1. In the library or IMC, look under topics like "desalinization" or "resources from the sea". You might want to write to corporations like Westinghouse and Fairbanks Morse before starting the project.
2. Andrews, Keith. Beneath the Oceans. New York: Grosset & Dunlap, 1973.
3. World Book Encyclopedia. Chicago: Field Enterprises Educational Corporation, Vol. 21 (Water/Fresh Water from the Sea), 1977.

Some of the most interesting and spectacular rivers and lakes can be found miles beneath the Earth's surface. How do we find these bodies of water and what do we use them for?

19

MATERIALS

Access to reference materials, access to local resource persons who drill wells and who are familiar with the local underground water supply.

PROCEDURES

1. Find a map of North America that indicates where the major regions of underground water are located. Are these supplies related to major surface water (lakes, rivers) supplies? Trace the origins of water in 2-3 regions of North America.
2. Locate the Ogalka region of underground water. What states does it affect? What are the main uses of water from this region? What is its origin?
3. What is an aquifer? Make a diagram of one. What can you compare it to that exists above ground? What kinds of rocks make good aquifers? What natural characteristics does a good aquifer have?
4. How was the rock formed where you usually find aquifers? How does this relate to the different layers of the aquifer itself and the layers above and below it?
5. Springs are often "outlets" for underground water. Can you find any springs in your local area? Ask your local soil conservation office for help in locating places where you can see springs.
6. Trace the source of the water you drink as far as you can. Contact your local water utility for help in this search. (If your water comes from a lake, trace the sources of water other than direct rain that feed the lake.)

EXTENSIONS

1. Explain what is meant by the common statements you hear such as, "the water table has been lowered", or, the "well went dry". Also, why is it called a water "table"?

HIDDEN WATER

2. Ask a local well driller to help you identify a person who is called a "water witch". Interview the "water witch" and ask him/her what equipment he/she uses, how he/she goes about locating supplies of underground water for drillers and how successful he/she has been in finding water.
3. Ask a local well driller or the local sanitation or water department how deep the underground water supply is in your area. Chart the different depths on a map of the area. What is the rate of flow from wells in your area?
4. Make a map that shows sources of underground water in North America.

REFERENCES/HINTS

1. Check with local resources like the Water Utility Department, Soil Conservation Service or other municipal or county agency as well as well drilling firms for information on the underground water supply.
2. Matthews, William H. The Story of the Earth. New York: Harvey House, Inc., 1968.

Let's get right to the heart of this activity. It's about your pulse. What makes your heart beat faster or slower? A little experiment may give you the answer.

20

MATERIALS

Access to reference material and a stop watch.

PROCEDURES

1. Go to your library or IMC, or contact your school nurse to find answers to these questions:
 - a. What are the different methods used to determine pulse rate?
 - b. Do you have to count the beats for a full minute to measure the pulse rate?
 - c. What happens to your pulse rate after exercise? What about after a meal?
 - d. Is a dog's pulse greater than a human's? How about an elephant's?
 - e. On the average, is there a difference between boys' and girls' pulse rate?
 - f. Is there a difference between the pulse rate of children and adults? . . . a baby?
2. Do this activity with a partner. Stand still for two minutes. Then have your partner count your pulse rate for 15 seconds. Record your data on a chart like the one below. (Note: 0 knee bends is the resting rate.)

Number of Deep Knee Bends	0	3	6	9	12	15
Pulse Rate each 15 Seconds						

Next, do three deep knee bends without stopping. Have your partner count your pulse rate immediately after you finish the deep knee bends. Record your data. Wait until your pulse rate returns to about the first count you made. Then, do six deep knee bends, and record your pulse rate immediately. Rest again. Repeat this procedure with nine, twelve, and fifteen deep knee bends. Graph your data.

THE BEAT GOES ON

3. Use the data you have gathered and your graph from Procedure 2 to help you make the predictions which are asked for below. Graph both your predictions and the results. (Place an X on the graph for each prediction, and place a dot to show your actual data.)
 - a. Predict your pulse rate after two, eight and fourteen deep knee bends. Place an X on the graph for each prediction. Collect the data to test your predictions. Record these data as dots on the graph. How accurate were your predictions?
 - b. Predict how many deep knee bends it will take to make your pulse beat 22 times in 15 seconds; 28 times in 15 seconds. Put an X on the graph for each prediction. Collect the data to test your predictions. Record your data as dots on the graph. How accurate were your predictions?

EXTENSIONS

1. Repeat the procedure using a jump rope to increase the pulse rate.
2. Repeat the procedure by running various distances such as 50 meters, 100 meters, 150 meters, etc.

REFERENCES/HINTS

1. Disney's Wonderful World of Knowledge. The Danbury Press, Vol. 15, 1973.
2. World Book Encyclopedia. Chicago: Field Enterprises Educational Corporation, Vol. 15 (Pulse, p. 791), 1977.

One person's blood is pretty much like another person's blood--right? Not really. Actually there are four different types of blood, and it may save your life someday if you know the difference.

21

MATERIALS

Access to reference materials and blood typing equipment and materials.

PROCEDURES

1. Locate information on the four types of human blood (A, B, AB, and O). What is meant by the term antigen? How did scientists name these four blood types? What makes the four types different from each other?
2. Find information on how the blood types can be matched for transfusions. Why are individuals having group O blood often called universal donors? Why are individuals having group AB blood often called universal receivers?
3. See if you can locate information on the relation of a certain blood type to a certain population. Are there specific blood types which are dominant in specific populations? How could this be explained?
4. Is it possible to determine the type of blood a new baby will have by studying the blood types of the parents? Explain.
5. Compare the blood of humans to the blood of fish, amphibians, reptiles, or birds. Do any of these groups have different blood types?
6. Contact your local Health Department to find out more about determining human blood types and for a simple method and equipment which you could use to determine the different blood types of the students in your class or school. Determine the blood types of 25 students. Compare the ratio of their types to the general population.

EXTENSIONS

1. Investigate the Rh factor in human blood. Why is this term important to the birth of human babies?

IS IT YOUR TYPE?

2. Contact your local Health Department to find out other factors besides blood type and Rh factor that have to be considered in blood transfusions.

REFERENCES/HINTS

1. World Book Encyclopedia. Chicago: Field Enterprises Educational Corporation, Vol. 2, (Blood Types, p. 327), 1977.

Beating over 70 times a minute, 60 minutes an hour, 24 hours a day--your heart beats more than 100,000 times a day. With each heartbeat, blood is pumped to all parts of your body. How does the heart work? How can you protect your heart? What methods are being used by doctors in modern heart surgery?

22

MATERIALS

Access to reference materials, diagrams or actual hearts from a frog and a fish.

PROCEDURES

1. Investigate the parts of the human heart and the function of each part. Make a large drawing of the heart and label each part. Be sure to include the following parts: arteries, veins, aorta, vena cava, right auricle, left auricle, right ventricle, left ventricle, pericardium, and septum. How does the function of the right side of the heart differ from the left side? Explain what is meant by a beat of a heart. Identify the changes which take place in the heart as a baby grows into a child and then into an adult.
2. Compare the human heart to the heart of the frog and fish. (Note: The Biology teacher at a High School could probably help you obtain a frog and fish heart.) How is the fish heart different from the human and frog heart? Why do you think the human heart evolved as it did? (Hint: What did primitive aquatic animals use as breathing organs? What do mammals use today?) Where in the body is the heart of a fish located? The heart of the frog?
3. Cardiovascular diseases cause over half of all deaths in the United States. Locate information on the major diseases of the heart. What precautions can you take to prevent heart diseases? What happens to the heart when a heart attack occurs? What is meant by the term, coronary thrombosis? Make a list of factors which may cause heart attacks. Why are foods that contain cholesterol harmful? List foods which are high in cholesterol. What foods do doctors recommend instead of foods which contain cholesterol?

EXTENSIONS

1. Investigate what is meant by the term "blue baby". What is done to protect the life of a "blue baby"? Explain.

HAVE A HEART!

2. Contact the American Heart Association, 44 East 23rd Street, New York, NY 10010 to get information on some of the methods being used in modern heart surgery. Also try to find out some of the heart-surgery techniques which are in the experimental stage.
3. Investigate the history of heart transplants. What are the major problems involved in such surgery and post-surgery?
4. Go to a local slaughter house or freezing plant to see a cow or pig heart. If possible, cut through the chambers of the heart and observe the muscles, arteries and veins related to the heart. Make a diagram of this heart.

REFERENCES/HINTS

1. Contact your local Heart Association for information, photos and diagrams on the heart. Also ask them what they do in the local area to help people protect their hearts.
2. World Book Encyclopedia. Chicago: Field Enterprises Educational Corporation. Vol. 9, (Heart, p. 134), 1977.
3. Disney's Wonderful World of Knowledge. The Danbury Press, Vol. 15, 1973.

Have you ever noticed that some people are better listeners than others? Are some ears better than others? Do some people concentrate more than others when they listen? What do you know about the way people listen?

23

MATERIALS

Tape recorder and audio tape.

PROCEDURES

1. You will be designing an experiment to test the listening abilities of your classmates. All you need is a tape recorder, a blank tape and a little ingenuity.
2. Prepare a recording in the following way:
 - a. Record 5-10 seconds of a wide variety of sounds. You will need to number them by announcing their order on the tape. For example: you say "Number 1", then record the sound of a pencil sharpener as it works. Then, "Number 2", followed by a typewriter typing, etc.
 - b. Record 10-20 sounds. Use your imagination. Record unusual sounds and see how they work. Record high sounds, low sounds, soft sounds, scratchy sounds, etc., etc.
3. Make 20 copies of a test scoring sheet which leaves one blank space for each of the sounds you record. On one of the scoring sheets you should write in the correct answers to serve as a key.
4. Give the test you developed in Procedure 3 to your classmates. You can do this individually or in a group, but there can be NO talking.
5. Analyze the results. Who is the best listener in your class? What sound was the most difficult to recognize? What sound was the easiest to recognize?

EXTENSIONS

1. Revise your test to make it more efficient and reliable. See if you can determine the characteristics which a good listener has.

HEAR YE! HEAR YE!

2. Make a tape using only sounds you record in nature such as crickets chirping, water rushing over rocks, etc.
3. Take 16 mm slides of the sounds you are recording and see if people can match the sounds with the pictures.

REFERENCES/HINTS

1. Your IMC or library should have a tape recorder and blank tape available for your use.
2. Check with a teacher or specialist in audiovisual methods to help you use the tape recorder properly.

NOW YOU SEE IT--NOW YOU DON'T

Now you see it, now you don't. It isn't really magic, but optical illusions are a fascinating and interesting field to explore.

24

MATERIALS

Access to reference materials.

PROCEDURES

1. What is an optical illusion? Look it up in an encyclopedia. Are there different types of optical illusions?
2. Look at illustration A on the back of this card. Which is longer, the width or the height of the hat? Measure to find out. Were you surprised?
3. Look at illustration B. Do the vertical lines appear bent? Actually, they are parallel.
4. Look at illustration C. Read the words quickly. Now look at the triangle carefully. Do you see anything different? Was your original interpretation correct?
5. Look at illustration D. This is a hard one. Sometimes the front of the cube will face to the right, sometimes to the left.
6. Many books on light or optics will have sections containing optical illusions. Show them to your friends. Are they fooled also? What causes optical illusions?

EXTENSIONS

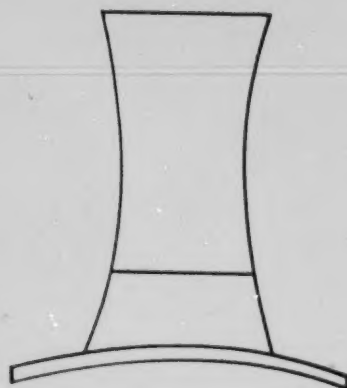
1. Find an example of the art of M.C. Escher. He relies heavily on optical illusions and his drawings are always fun to look at.
2. What is meant by the "blind spot" in the human eye?
3. See if you can draw an optical illusion of your own!

NOW YOU SEE IT--NOW YOU DON'T

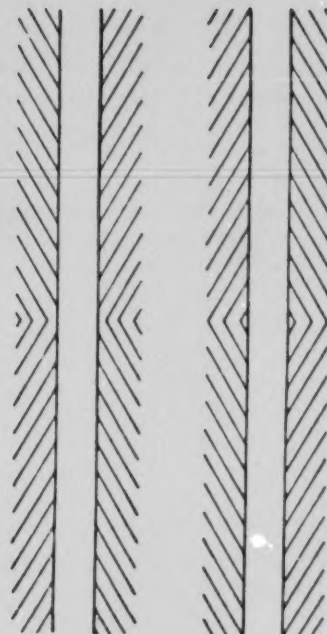
REFERENCES/HINTS

1. Mueller, Conrad G. and Mae Rudolph. Light and Vision. New York: Time-Life Books, 1969. (Illustrations from this reference.)

A.



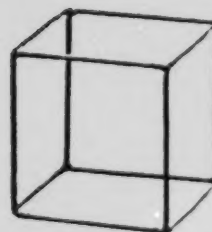
B.



C.



D.



How could two parents with blue eyes have children with brown eyes? Why do some families have both tall and short members? There are many interesting things to discover about the world of genetics and heredity.

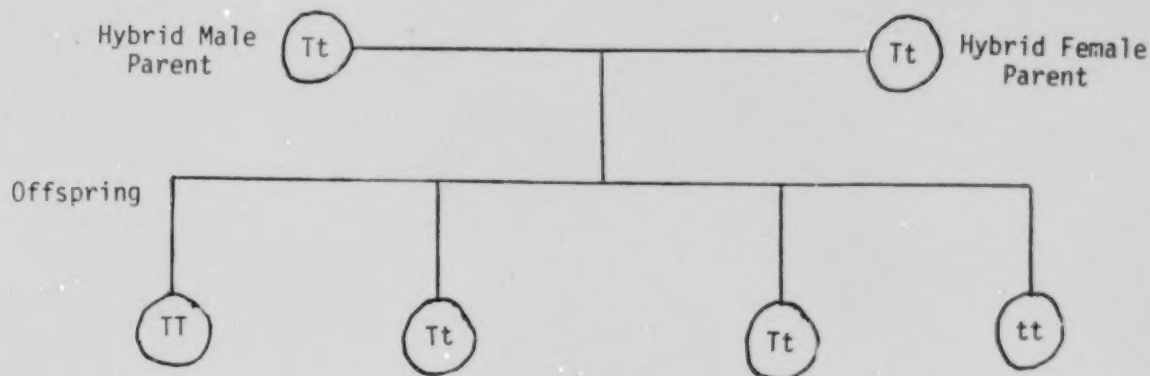
25

MATERIALS

Access to reference materials and 15-20 pieces of PTC paper.

PROCEDURES

1. Become familiar with the following terms: trait, chromosome, gene, dominant, gamete, recessive, blended inheritance, hybrid, and self-pollination.
2. Investigate the experiments done by Gregor Mendel in the mid-1800's. Explain Mendel's Law of Dominance. If pure tall pea plants (TT) are crossed with pure short pea plants (tt), what type of plants are produced? Explain why this is so. Scientists often use symbols such as TT and Tt when they explain the passing on of specific traits. Find out what these symbols mean. Explain Mendel's Law of Segregation, using the heredity chart below.



Of the four offspring above, how many are pure short? How many offspring are pure tall? How many offspring are hybrid tall? What is the ratio of these numbers to each other?

HAND-ME-DOWN GENES

3. Explain how chromosomes and genes control heredity. How many genes does each parent carry for each inheritance trait? How many genes does a gamete carry for each trait? What is meant by the term linkage? How does this term relate to the varied heights of humans? Is it possible that a new gene can appear in an organism if it was not present in the parents? Explain. Define the terms mutant and mutation. In what ways can a mutation be harmful to an organism? Make a list of mutations which have helped different organisms to survive.
4. If the mother is blue-eyed and the father is brown-eyed, what are the chances of blue-eyed children? (Hint: The father is hybrid for eye color.) Show the cross using a heredity chart like the one in Procedure 2.
5. Obtain 15-20 pieces of PTC paper. These are strips of paper treated with the chemical PTC. PTC is tasteless to about 70% of all Americans. Get enough strips to test your entire family. Taste is dominant (T) and non-taste is recessive (t). Try the test on 15-20 students in your class. Make a chart of the results.

EXTENSIONS

1. Contact an owner of a greenhouse to find out about the process of breeding to obtain desired traits in certain plants. What are some problems which may result from this process?
2. Contact your local county extension agent or veterinarian and find out how farmers use genetics in developing their milking herds.
3. Develop a heredity trait chart that shows how more than one characteristic can be carried at a time and all of the possible outcomes. Ask the high school biology teacher for help and references to lead you into the more complex areas of genetics.

REFERENCES/HINTS

1. Oxenhorn, Joseph M. Pathways in Science: the Next Generation. New York: Globe Book Co., Inc., 1975.
2. World Book Encyclopedia. Chicago: Field Enterprises Educational Corporation, Vol. 9, (Heredity p. 192), 1977.

LIQUIDS: THICK OR THIN?

Can you think of a liquid which you might consider to be thick? How about a thin liquid? Scientists have developed a way to accurately measure the "thickness" or "thinness" of liquids. You can get involved in these measurements by carrying out the procedures below.

26

MATERIALS

Balance scale, graduated cylinder, samples of liquids such as, milk, fruit juice, alcohol, molasses, Karo syrup, etc., and beakers or glasses.

PROCEDURES

1. Determine the weight of 25 milliliters of water. (You must weigh the beaker empty, then the beaker with 25 ml of water in it. Then, subtract the difference to get the weight of the water.)
2. Divide the weight of the water by 25 milliliters to find its density. For water, this should be nearly 1 g/ml.
3. Repeat the procedure with several other liquids and record the data on a chart. Why are the results different? Explain.

EXTENSIONS

1. Densities of liquids are listed in scientific handbooks as specific gravities. The specific gravity is usually listed in grams/ml in comparison to water at 1 gram/milliliter.
2. Using a specific gravity table, determine the weight of 25 milliliters of oil, mercury, ether, ethyl alcohol, etc. How does each of these compare to water?

REFERENCES/HINTS

1. Check in a high school chemistry book under the heading "density of liquids".
2. Find densities of liquids in a handbook of chemistry.
3. World Book Encyclopedia. Chicago: Field Enterprises Educational Corporation, Vol. 5, (Density, p. 120), 1977.

The design of a boat helps to determine how much cargo it can hold. What makes for a good boat design? Try your hand at making boats of different designs.

27

MATERIALS

Plastic-based clay, access to a sink or a bucket of water, a set of gram weights, and an accurate gram scale.

PROCEDURES

1. Measure out exactly 125 grams of clay. (Note: Do not use earth-based clay because it will dry and harden.)
2. Experiment with clay, designing different types of boats: round-bottom, flat-bottom, narrow, wide, etc.)
3. Test designs by floating them in water. Add weights to each boat until it sinks. Record the weight that each boat will support. The object, of course, is to design a boat which will hold the most weight.
4. What type of design holds the most weight? What characteristics does this design have? Explain.

EXTENSIONS

1. Sponsor a class contest to find out who can design the boat that will carry the heaviest cargo.
2. Would liquids other than water affect the boat's ability to hold weight? How about salt water or sugar water? Explain.

REFERENCES/HINTS

1. Leyden, Michael B. "Clay Boats - Classroom or National?" The Science Teacher. Vol. 40, No. 8, November, 1973, p. 42.
2. Disney's Wonderful World of Knowledge. The Danbury Press, Vol. 4, p. 12-45, 1973.

Did you realize that when ice changes into water, heat is added to the ice but the temperature does not change? This sounds confusing, but once you have solved the mystery of the melting ice you will understand an important idea in science.

28

MATERIALS

The prepared graph on reverse side of card.

PROCEDURES

1. What do the horizontal and vertical axes on the graph represent? How are they divided?
2. Look at the line on the graph. Notice especially the level sections at 0°C and 100°C . These are puzzling portions of the graph. Think about them carefully.
3. Now, without consulting reference books, prepare a short oral or written report which includes your explanation of the graph. Be sure to explain the level sections. Be as complete as you can.
4. Check in a high school chemistry textbook or in an encyclopedia for the correct answers. Compare your explanation to the one in the book.

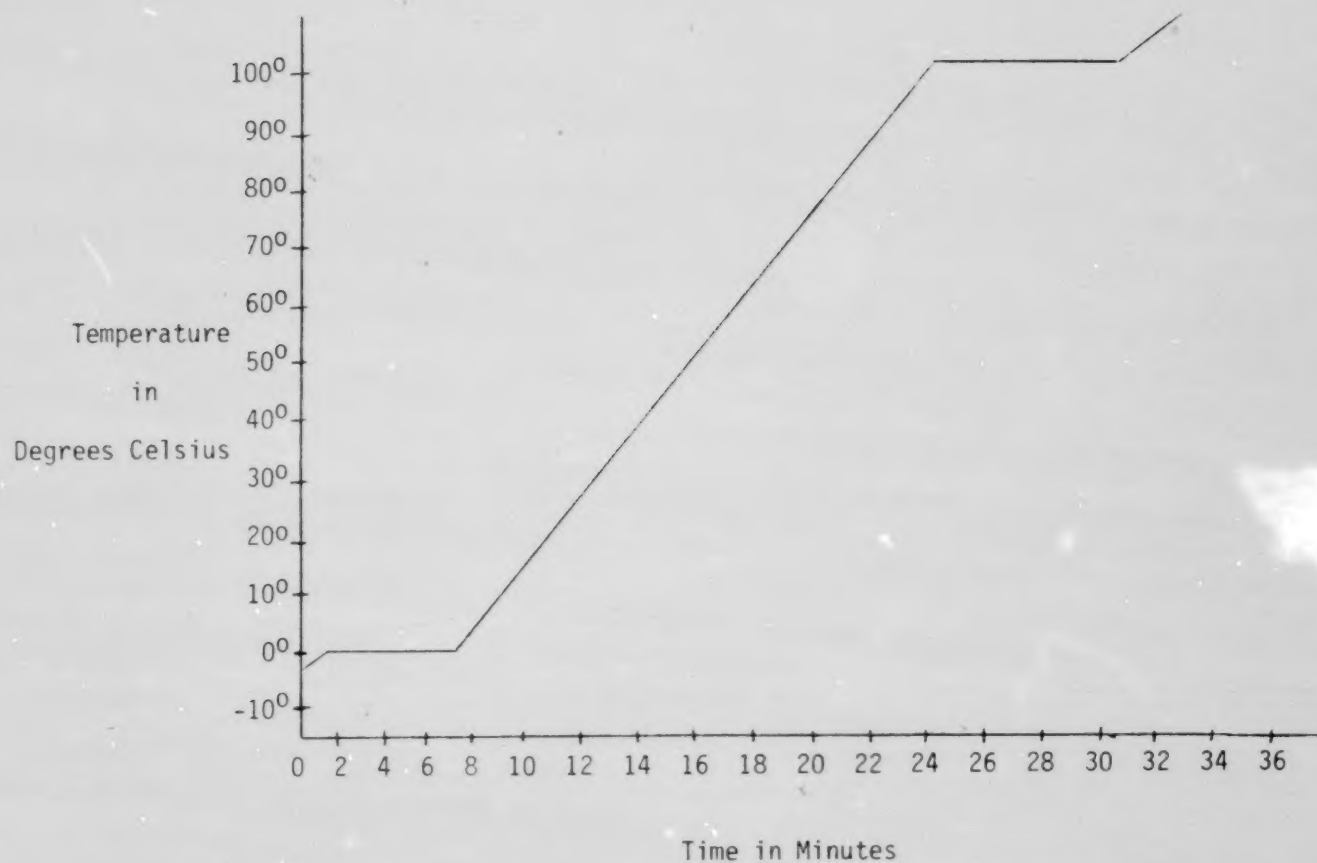
EXTENSIONS

1. Make a similar graph for other liquids, using data from a chemistry handbook.
2. Design a simple experiment to get your own data on another liquid.

REFERENCES/HINTS

1. Check high school chemistry texts under the topics of melting, change of state, heat of fusion, heat of vaporization.
2. Contact the high school chemistry teacher for help and/or discuss your explanation with him/her.

MYSTERIOUS MELTING



THE CHANGING STATES OF WATER

What causes a liquid, like water, to "climb" up a strip of paper? Isn't this going against the force of gravity? You can find out by following the procedures below.

29

MATERIALS

Water, beakers or jars, strips of blotting paper or some other absorbent paper, paper to record data, and a ruler.

PROCEDURES

1. Prepare a data table including columns for variables and for the height to which the liquid climbs.
2. Fill a beaker half-full of water. Hold one end of a strip of blotting paper and carefully dip the other end 2 cm into the water. How high does the liquid climb up the paper?
3. Repeat the experiment, being careful to do exactly what was done before. Was the height of the climb the same?
4. Make a list of the things which might affect the height of the climb, (width of the paper, depth of the water, outside humidity, etc.).
5. Design an experiment which will test the factors on your list. For example, do three tests where only the water level in the beaker is changed. Record the results of your tests under the variables column marked "water level".
6. Which variable caused the greatest change? Try to explain why.

EXTENSIONS

1. Capillary action can also be observed using small, hollow glass tubes. Explain capillary action to a friend.
2. Identify situations in everyday living where capillary action occurs. How many can you think of?

CLIMBING LIQUIDS

REFERENCES/HINTS

1. If blotting paper is unavailable, use paper towels.
2. See SAPA II module #62 if it is available.
3. Read about capillary action in junior and senior high school science books.

Have you ever watched a candle burn and wondered about what was really happening? Actually, many chemical and physical changes are occurring. So, let a burning candle be your guide and follow the procedures below to find these changes.

30

MATERIALS

Access to reference materials on matter (chemistry), a 10-15 cm candle, and ice cubes.

PROCEDURES

1. Identify the three states of matter and the characteristics of each.
2. How can you change matter from one state to another? Explain this starting with an ice cube. Can you also use a burning candle to explain the three states?
3. Define the following terms: fact, principle, concept, theory. Now relate them to a burning candle.
4. The processes of science are ways by which scientists gather information. They can be identified as follows:

Observation
Classification
Inferring/Predicting
Measuring
Communicating

Interpreting Data
Making Operational Definitions
Formulating Questions and Hypotheses
Experimenting
Formulating Models

Use your lighted candle and see how many of these processes can be carried out. A score of seven for the ten processes is very good. A score of eight or more is excellent.

(Consult junior or senior high school science books, or the SAPA II or SCIS elementary programs, for more information on each process of science.)

5. List all of the facts, principles, concepts and theories that you can gather about the burning candle using the processes listed in Procedure 4 above.

SEEING IS BELIEVING

EXTENSIONS

1. Define burning. What kind of a change is it? Why? Is it different or similar to heating up a piece of metal until it is red hot and then cooling it down again? Explain.
2. Can you identify the relationship between matter and energy when a candle burns? Explain your idea to a science teacher and discuss your ideas with him/her. Were your ideas correct?

REFERENCES/HINTS

1. Junior and senior high school science books.
2. SAPA II, SCIS and other elementary science programs that stress the processes of science.
3. Keen, Martin L. The How and Why Wonder Book of Chemistry. Charles E. Merrill Books, Inc., 1961.

THE SUFFOCATING CANDLE

Perhaps you have tried an experiment similar to this one when you placed jars of various sizes over a candle and measured the burning time of the candle. In this experiment you will discover a variation of "The Suffocating Candle" activity.

31

MATERIALS

Candle, 1 large jar, 10 blocks of the same thickness (about 1½ centimeters), and a stopwatch.

PROCEDURES

1. Place the large jar over the burning candle and measure how long it takes until the candle burns out. Record your data on a chart like the one below. (Note: The number of blocks would be zero for the first trial.)

Number of Blocks	0	1	2	3	4	5	6	7	8	9	10
Burning Time in Seconds											

2. Now, place the candle on 1 of the small blocks. Light the candle and place the large jar over the candle again. Measure the burning time of the candle, and record your data on your chart. Repeat the activity using 2, 4, and 7 blocks. Record your data each time.
3. Graph your data. Be sure to put "Number of Blocks" on the horizontal axis and "Burning Time in Seconds" on the vertical axis.
4. Predict the burning time for 3, 5, 6, 8, 9, and 10 blocks. Place an "X" on your graph for each prediction; then find the actual burning time to test your predictions. Record these data as dots on the graph. How accurate were your predictions?
5. Identify some variables which may affect your results (e.g., length of wick on candle).

THE SUFFOCATING CANDLE

6. Look up the words interpolating and extrapolating in a dictionary. How do these words relate to the activity you have just completed?
7. What in air really burns? What does not burn? In what ratios do these elements occur in air?

EXTENSIONS

1. Repeat the activity using a different sized candle or jar. Compare these results to those of the first activity.
2. Combine your data with a partner's data. Take the average of the two sets of data. Graph the results.

REFERENCES/HINTS

1. Investigate the process of burning in junior high school science and high school chemistry books.
2. Discuss your data with your teacher or a science teacher to see if it is reasonable.

All you need to do is borrow a ruler and a handful of paper clips and you can build a balance scale which can be used to demonstrate many interesting properties.

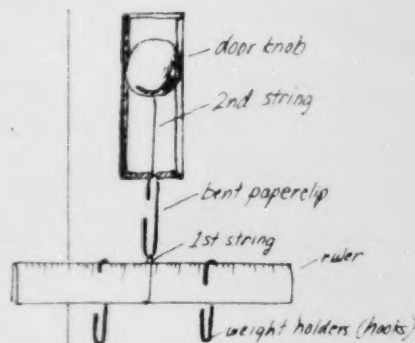
32

MATERIALS

A meter stick or English ruler, string, paper clips, and paper to record data.

PROCEDURES

1. Construct the lower-balance in the following way: Wrap a piece of string, once, around the center of the ruler, tying it securely. Hook a paper clip under this string. Tie a second piece of string to the other end of the paper clip. Then tie this second string around a door knob, leaving the ruler swinging freely as shown on the right:
2. Then, bend three paper clips so that one end will hook around the ruler, and the other end will hang below the ruler, hooking up, so that other paper clips could be hung on each of them.
3. Where is the fulcrum of this balance?
4. Place two of the paper clip hooks at the 4 and 8 inch marks on the ruler. Put 5 paper clips on the "4" hook. How many paper clips are needed on the "8" hook to balance the scale?
5. Put one hook at the 4 inch mark, another at the 10 inch mark. Put 5 paper clips on the "10" hook. How many paper clips are needed on the "4" hook?
6. Experiment with other weights and distances. Keep a table of your results.
7. Put two hooks on one side of the fulcrum and one on the other. What kind of results do you get from this set up?



KEEPING YOUR BALANCE

8. Look at your table of results. Can you see any patterns between the weights and distances? How would you put that pattern into words?

EXTENSIONS

1. Place several hooks on one end of the balance-scale, putting weights on all of them. Now, using just one hook on the other side, guess the number of weights that would be needed to balance the other side. You will need to place the single hook at exactly the right position.
2. Using a meter stick or metric ruler, prepare a set of directions for another student to carry out the procedures you just completed. Does it matter which measuring scale you use?
3. We have used the word "weight" here. How does weight differ from "mass"? Explain.

REFERENCES/HINTS

1. See SAPA II, Module #78 for more information.
2. Ask your teacher to help you locate information on balance scales.
3. World Book Encyclopedia. Chicago: Field Enterprises Educational Corporation, Vol. 17 (Scale, weighing, p. 142), 1977.

Some solid and liquid materials heat up quickly and others take a long time. In this experiment you will determine which materials heat and cool more rapidly and some of the characteristics of these materials.

33

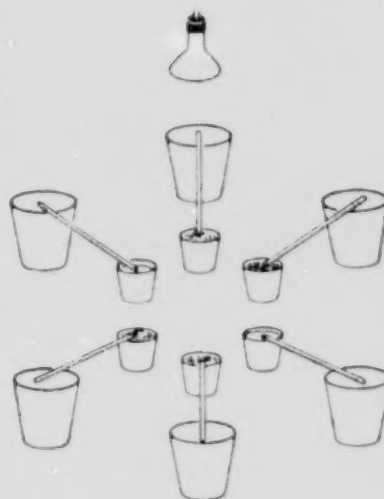
MATERIALS

6 shallow containers, 6 Celsius thermometers, timing device, 6 larger containers (used to support thermometers), light bulb and support (150-Watt), 6 different solid or liquid materials such as sand, soil, powdered charcoal, and water (some solid materials may also be moistened).

PROCEDURES

1. Arrange the six shallow containers as shown on the right:

Fill each container with a different solid or liquid material. (Some solids may also be moistened.) Support a thermometer in each container as shown in the diagram. The bulb of each thermometer should be barely covered by the material in the container. Place a 150 watt bulb about 25 or 30 cm above the containers. Center the light so it is shining equally on all containers.



2. Complete the chart below using the data you collected in Procedure 1.

Thermometer Reading ($^{\circ}\text{C}$)						
Material	Light Off	Light Turned On				Light Off
	At Start of Experiment	After 1 min	After 3 min	After 5 min	After 8 min	After 5 minutes Cooling
			67			

cont.

HEATING UNEQUALLY

3. Using your chart, answer the following questions:
 - a. What solid material changed the most in temperature?
 - b. Did the temperature of the solid or liquid materials increase the most?
 - c. After cooling, did the temperatures of the solids or the liquids change the most? How do you explain your observations?
 - d. Can you find anything that happens in your daily life where materials heat differently? (e.g., a thermostat)

EXTENSIONS

1. Graph the results from your chart. (Put time in minutes on the horizontal axis and temperature on the vertical axis.)

REFERENCES/HINTS

1. Be sure to turn off the light if the fluid in any thermometer comes close to the top. Make sure the thermometer bulbs are covered equally and not too deeply.
2. Check with junior or senior high school science teachers for reading materials and other information on specific heat.

NUCLEAR CHAIN REACTIONS

Using only simple equipment, you can make a model of a nuclear reactor. This model will give you an idea of what actually happens when nuclear fission takes place.

34

MATERIALS

An empty aquarium (about 4-5 gallons), 15-20 mousetraps, 15-20 ping pong balls, and a heavy sheet of cardboard or wood.

PROCEDURES

1. Cut a hole in the cardboard, big enough to put a ping pong ball through, near one corner of the cardboard. The cardboard itself must be big enough to cover the top of the aquarium with about 3 cm extending over all the sides.
2. Carefully place the mousetraps on the bottom of the aquarium next to each other. Set them so that when the trap is sprung it will flip a ping pong ball into the air. (Note: You may want to set the traps and then carefully place them on the bottom of the aquarium.)
3. When all the traps have been set, place the cardboard over the aquarium. Then drop a ping pong ball through the hole. If all has gone well, all of the traps should have sprung quite rapidly.
4. Repeat the experiment, using fewer, or more mousetraps. Is there a point where the reaction does not take place? Keep a record of your attempts and relate it to your explanation.

EXTENSIONS

1. How does this experiment relate to nuclear reactors? In an encyclopedia, look up nuclear reactor, chain reaction, nuclear fission, and critical mass. Can you now see the relationship?
2. Prepare a demonstration for the rest of the class. Share with them what you have learned.
3. Your experiment illustrated nuclear fission. How does this compare with nuclear fusion? Explain.

NUCLEAR CHAIN REACTIONS

REFERENCES/HINTS

1. The empty aquarium, and perhaps the mousetraps, may be borrowed from a nearby junior or senior high school science department or from fellow students. Old ping pong balls should not be hard to find.
2. Disney's Wonderful World of Knowledge. The Danbury Press, Vol. 9, 1973.
3. Miller, Peter G. "HTGR: A Safer Way to Nuclear Power." Popular Science, Vol. 206, No. 2, February 1975, p. 66.
4. Student Encyclopedia. Chicago: Rand McNally & Company, 1972.

Have you ever wondered about the word submarine? Sub means below and marine means sea. A submarine, then, goes below the sea. How does the submarine get below the sea and what does it do there?

35

MATERIALS

Access to reference materials, an empty pop bottle and a cork.

PROCEDURES

1. Go to your IMC or library to find information on submarines. Investigate to find the answers to these questions:
 - a. What are the differences between the two basic types of submarines-- attack submarines and ballistic missile submarines?
 - b. How does the submarine withstand the water pressure when it is submerged?
2. How does the submarine "dive"? Explain the terms positive, negative, and neutral buoyancy. Do the following activity to help you understand the principle of buoyancy and how it relates to the submerging and surfacing of a submarine.
 - a. Put a cork in an empty bottle and place it in a sink filled with water. Observe what happens. What term describes what happens?
 - b. Let water into the bottle until it is full. What happens? What do you think would happen if you let in only enough water so that the pop bottle weighed the same as an equal volume of water? See if you can do this. How does this activity relate to the flooding of the ballast tanks in a submarine?
3. Investigate how the submarines are powered. Why does the U.S. no longer build diesel-powered submarines? What is used to power the giant nuclear submarines? Describe the process which is used to produce the necessary heat in a nuclear-powered submarine. What does the steam generator do?
4. How is oxygen produced inside the submarine? (Hint: The term electrolysis may help you.) How do the people in a submarine obtain fresh drinking water?

VOYAGE BENEATH THE SEA

5. Trace the major advancements in submarine construction from the "Turtle" in 1776, to the present day "Trident".

EXTENSIONS

1. Contact the information officer at your local Navy Recruiting Station for more information on submarines.
2. Make a miniature submarine called a Cartesian diver using a glass bottle, an eye dropper and water. Look in a physics book or ask the high school science teacher to help you.

REFERENCES/HINTS

1. Andrews, Keith. Beneath the Oceans. New York: Grosset & Dunlap, 1973.
2. Dukert, Joseph M. Nuclear Ships of the World. New York: Coward, McCann & Geoghegan, Inc., 1973.
3. Engel, Leonard. The Sea. New York: Time-Life Books, 1969.

HOW HIGH DOES IT BOUNCE?

If you dropped a golf ball from a tall building, how high would it bounce? Here is an experiment to help you figure that out and to be able to predict it under some different conditions.

36

MATERIALS

A golf ball, shelf paper, recording paper, and graph paper.

PROCEDURES

1. Prepare a wall chart which will be used to measure the bounce-height of a golf ball. To make the chart, use a large sheet of shelf paper or newsprint that is at least 1.5 meters high. Starting at the bottom, mark off horizontal lines at 1 decimeter intervals. Label the lines according to their distance from the bottom of the chart. Then carefully tape the chart to a convenient wall so that the bottom of the chart just touches the floor.
2. Prepare a table, to record test results. The table should include the height from which the ball was dropped (the drop-height) and the height to which the ball rebounded (the bounce-height). Leave room for several trials to be taken at each height.
3. Drop the golf ball from the 3 decimeter mark. Observe and record the bounce-height. Measure this height to the nearest $\frac{1}{2}$ decimeter. Make several trials and then determine the average.
4. Repeat step 3, dropping the ball from 4 dm, 5 dm, 6 dm, 7 dm, etc.
5. Using the data from the table, prepare a graph to show the relationship between drop-height and bounce-height. Let one axis of the graph be the drop-height, measured in decimeters. Let the other axis be the average bounce-height. Plot points as they are taken from the table. Can a straight line be drawn between the points? A smoothly curving line?
6. Extend the line on the graph until a drop-height of 10 meters is reached. What would the bounce-height be? What might possibly interfere with this prediction if a ball were actually dropped from 10 meters? Explain.

HOW HIGH DOES IT BOUNCE?

EXTENSIONS

1. Repeat the experiment with different types of balls.
2. If possible, test a prediction by dropping a ball from a ladder, window or some other spot 5-10 meters above ground.

REFERENCES/HINTS

1. A seldom-used hallway may be a good place to put the chart.
2. See SAPA II, Module #48 if it is available.

You have probably heard of Albert Einstein's theory of relativity which was published in 1905. One part of this theory suggests that at very, very high speeds time slows down. This suggests that an astronaut traveling in space at high speeds would age less during a year than he or she would on the Earth.

37

MATERIALS

Access to reference materials on relativity. (A very good source is the Time book from the Life Science Library, 1966, pages 144-165, which is referenced below.)

PROCEDURES

1. Read basic reference materials on Einsteins's theory of relativity, first published in 1905.
2. How can very, very high speeds be defined?
3. How were Einstein's theories different from Newton's earlier laws? Why? Who was right? Under what circumstances? Why was Einstein's theory considered "revolutionary"?
4. Why do astronauts traveling through space at high speeds age more slowly than they would on Earth? Explain. What would happen to twins if one stayed on Earth and the other spent 10 years in a space craft traveling at high speeds?
5. How does high speed travel affect an "Earth-type" clock? Explain.

REFERENCES/HINTS

1. Look through the school IMC and city library for books, films and filmstrips on relativity.
2. Ask your junior high school science teachers or high school physics teacher for information on relativity.
3. Goudsmit, Samuel A. and Robert Clairborne. Time. New York: Time-Life Books, 1966.

Electrical motors probably seem like a hidden mystery to most people. But, using only simple materials you can build an electric motor which actually works!

38

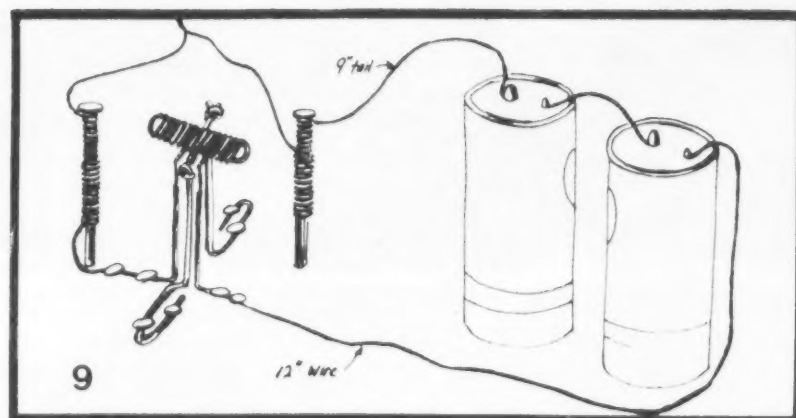
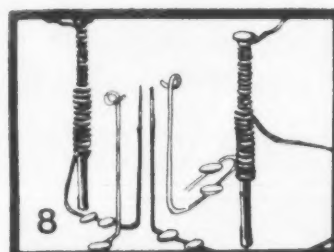
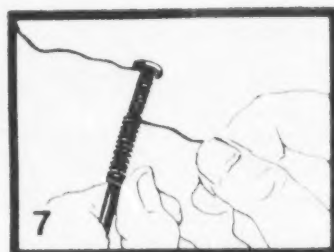
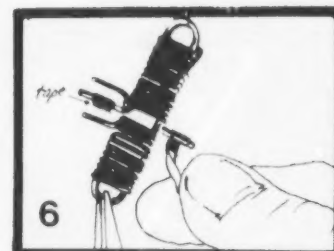
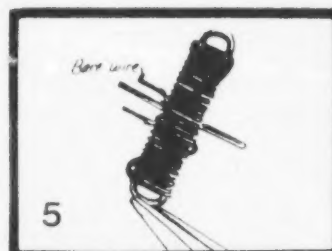
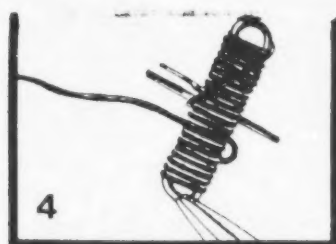
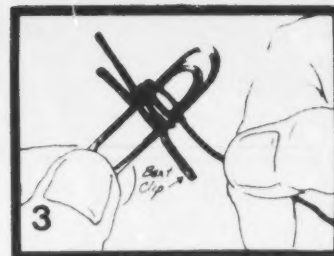
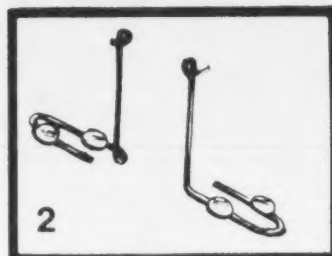
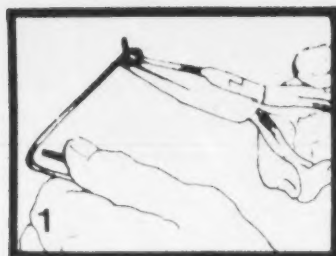
MATERIALS

8 thumb tacks, two-inch nails, needle-nosed pliers, electrical tape, 3 paper clips, 2 one-and-one-half volt dry cell batteries, a wooden board (5"x6"), a small spool of #70 insulated copper wire, and a knife.

PROCEDURES

1. Take one of the paper clips and straighten its smaller loop, then twist it so that it stands upright at right angles to the larger loop. Then use the pliers to bend a tiny loop in the upright end. (See Diagram 1)
2. Attach the paper clip to the board using two thumb tacks. The small loop should be up in the air. The thumb tack should be loose enough to allow the paper clip to slide freely back and forth.
3. Repeat steps 1 and 2, positioning the second clip about one inch from the first clip. The paper clips are the supports for the axle of the motor's rotor. (See Diagram 2)
4. To make the rotor, bend the ends of a third paper clip so that they extend $\frac{1}{2}$ inch perpendicular to the clip's loops. (See Diagram 3)
5. Leaving one inch free, wrap the copper wire tightly around the rotor clip, working out from the middle. Wind the wire closely, but do not bend the clip out of shape.
6. After wrapping about 20 coils, take the wire back to the center and wrap, in the same direction, an equal number of coils around the other half. Then, bring the wire back to the center clip. (See Diagram 4)
7. Cut the ends of the wire so that they are slightly shorter than the projecting ends of the clip. Then scrape the coating off the wires ends to expose the bare copper. These two ends should be bent in the same direction. (See Diagram 5)
The ends serve as the rotor's commutators.

MAKE YOUR OWN MOTOR



8. Next, take two strips of electrical tape, each about $\frac{1}{4}$ inch wide and 2 inches long and wrap one around each end of the axle, or projecting ends (the rotor clip). (See Diagram 6)
9. Next, make the stationary magnets. Wrap each nail with wire, leaving about 9 inches of wire free close to the head. Wind the wire evenly for about 2 and $\frac{1}{2}$ inches down from the top. Then back up, making a double layer, for about 1 and $\frac{1}{4}$ inches. Leave about 6 inches of wire sticking out from the middle of each nail and cut it. Each nail should have a 9-inch tail and a 6-inch tail. (See Diagram 7)
10. Hammer the nails into the board about $2\frac{1}{2}$ inches apart. (See Diagram 8)
11. Thumb tack the 6-inch tail from one of the nails to the board. Lead it to within $\frac{1}{4}$ inch of either support and then bend it up so its end is slightly higher than the support. Do the same with an unattached, 12-inch length of wire. These form the brushes. (See Diagram 8)
12. After scraping $\frac{3}{4}$ inch of insulation from the two upstanding wires (the brushes), fit the axle of the rotor into the loops of each support so that the rotor's commutators, when twirling, will make contact with the brushes.
13. Twist the end of the 6-inch tail from the second nail around the end of the 9-inch tail from the first nail. (Scrape the ends of the wires to make solid metal-to-metal contact.) (See Diagram 9 for completed motor.)
14. The 9-inch tail from the second nail will connect with the center terminal of one of the batteries. Link the free end of the 12-inch wire to the side terminal of the other battery. A short wire, connecting the two remaining terminals completes the circuit. (See connections in Diagram 9.)
15. The motor is finished! You may need to give the rotor a gentle nudge. Also, both commutators must touch the brushes simultaneously. Also, the supporting clips must be adjusted to put the rotor in position.

EXTENSIONS

1. Trace the flow of current through the wires. How does the motor work? Can you find a use for your motor?

REFERENCES/HINTS

1. Hatkin, Jerome and Sidney Gulkin. The How and Why Wonder Book of Electricity. Charles E. Merrill Books, Inc., 1960.
2. Wilson, Mitchell. Energy. New York: Time-Life Books, 1967, pp. 132-135.

Our oil and gasoline are probably going to be used up in the next 25-50 years and will have to be replaced with some other kind of energy. The sun is one possible substitute. But there are some problems learning how to trap and use the sun's energy. Investigate some of these problems and maybe figure out some ways to solve them.

39

MATERIALS

Access to reference materials on the sun and solar energy; and materials to make a solar cooker.

PROCEDURES

1. Investigate the source of the sun's energy. How hot is the sun at its surface? What are the corona, solar flares, sun spots?
2. How do the terms reflection and absorption relate to the collection of solar energy on the Earth?
3. Make a solar cooker using cardboard, aluminum foil, plywood, tubing, and so on. It will cost under \$10.00. For directions, consult chapter 3 in Experiments with Solar Energy by D.S. Halacy, Jr., W.W. Norton and Co., Inc., New York, 1969, or another source. What principles are involved that ~~cause the food to~~ "cook" in a solar cooker? How can these same principles be applied to a solar furnace or oven?
4. How do houses and other buildings utilize solar energy for heating? Consult publications on this subject in your IMC or library. Also, check local home builders, U.S. Government publications, and references listed below.
5. Design and build a miniature solar home. Check out its ability to heat at different outdoor temperatures. Does it work?

REFERENCES/HINTS

1. Names of companies engaged in solar-energy applications along with solar products they are involved with are listed below:

Bell Telephone Laboratories
Murray Hill, NJ 07971

Do-It-Yourself Solar-Cell Kit

HERE COMES THE SUN

Edmund Scientific Corp.
Barrington, NJ 08007

Fresnel lenses, solar furnace
kits, solar batteries

Yellott Solar Energy Laboratory
9051 North 7th Ave.
Phoenix, AZ 85012

solar instruments, research
and testing

Zenith Sales Corp.
1900 North Austin Ave.
Chicago, IL 60639

solar radio

2. Britton, Peter. "World's Most Advanced Solar Home." Popular Science, Vol. 211, No. 1, July 1977, p. 92.
3. Halacy, D.S. Experiments with Solar Energy. New York: W.W. Norton & Co., 1969.
4. Wilhelm, John L. "Solar Energy, the Ultimate Powerhouse." National Geographic, Vol. 149, No. 3, March 1976, p. 381.

WHERE IN THE WORLD IS G.O. THERMAL?

PHYSICAL SCIENCE
ENERGY

GEOTHERMAL POWER

No, there really isn't a G.O. Thermal. But he does have a good friend named "Old Faithful". Actually, geysers like "Old Faithful" are examples of a form of energy which we are just beginning to learn about. It's called geothermal energy.

40

MATERIALS

Access to resource materials and an outline map of the world.

PROCEDURES

1. Define what is meant by geothermal energy.
2. Make a map of the world indicating the locations that have the potential for geothermal energy. Is this energy resource associated with any particular geological features? Explain using your map.
3. Investigate how Icelanders have harnessed the resource of geothermal energy. Indicate the variety of ways in which they have utilized it.
4. Make a list of the advantages and disadvantages of geothermal energy.
5. Where in the United States is geothermal energy a resource? Is it being utilized at this time? Is it possible to use geothermal energy for heating homes and buildings? Explain.

EXTENSIONS

1. Are the "hot springs" in Yellowstone Park and the "hot springs" in Arkansas related to geothermal energy? Explain.
2. Speculate on the statement: Geothermal energy could be "created" to heat a city of 10,000 population. Write a story about this possibility. Would it save the total amount of energy used?

REFERENCES/HINTS

1. Craighead, Karen and Derek. "A Walk Through the Wilderness". National Geographic, Vol. 141, No. 5, May 1972, p. 579; "Yellowstone at 100: Ageless Splendors of Our Oldest National Park", p. 604.

WHERE IN THE WORLD IS G.O. THERMAL?

2. Eaton, William W. "Geothermal Energy". Available from USERDA, Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830, 1975.
3. Henahan, John F. "Geothermal Energy . . . The Prospects Get Hotter". Popular Science, Vol. 207, November 1974, p. 96.
4. World Book Encyclopedia. Chicago: Field Enterprises Educational Corporation, Vol. 6 (Energy supply, p. 226a), 1977.

One of the most beautiful and amazing inventions of the ancient times is the sailing ship. Old time navigators could travel around the world using only the power of the wind. Why hasn't modern man made use of this potentially great source of energy?

41

MATERIALS

Access to reference materials, equipment and materials to build a windmill.

PROCEDURES

1. Investigate the subject, "What is and what causes wind?" Explain.
2. Trace the history of the use of wind as a source of power in the Netherlands and the United States. List its major advantages and disadvantages as an energy source. What are the most common uses of wind power in each country?
3. Research the past history and future potential of wind as a source of energy to generate electricity. Why did it die out and why is there renewed interest in it?
4. Build a miniature windmill. Try to use it to generate energy.

EXTENSIONS

1. Investigate the winds associated with tornadoes, cyclones, hurricanes. What other events are these "winds" associated with? In what region of the world are they most common?
2. Make a diagram to indicate how winds form and indicate their causes.

REFERENCES/HINTS

1. Hamilton, Roger. "Can We Harness the Wind?" National Geographic, Vol. 148, No. 6, December 1975, p. 812.
2. "Wind Power: How New Technology is Harnessing an Age Old Energy Resource", Popular Science, Vol. 204, July 1974, p. 54.

WHAT ABOUT EARTHQUAKES?

Although earthquakes can be very destructive to man and his environment, many important clues about the center of the Earth have been discovered by studying them. In this activity you will learn both about earthquakes and about the regions of the Earth's interior.

42

MATERIALS

Access to reference materials and a world map.

PROCEDURES

1. Go to your IMC or library and find out what scientists have learned about the regions of the Earth's interior. Describe the inner layers or zones of the Earth. Answer the questions below:
 - a. What do scientists believe is the temperature of the inner core?
 - b. What is the inner core made of? What is the outer core made of?
 - c. How do you know that the inside of the Earth is not composed of the same material as the surface? What evidence can you give to support your answer?
 - d. Can you guess the kind of material within the mantle?
 - e. What 3 kinds of rock make up the Earth's crust?
 - f. Make a diagram or model to show the layers of the Earth and the approximate depth of each layer.
2. Investigate how the study of earthquakes has helped scientists learn about the Earth's interior. What are the 3 different types of earthquake waves? How do these waves give clues about the center of the Earth? Explain how a seismograph works.
3. The chart below gives the latitudes and longitudes of areas where earthquakes have occurred recently. Plot the location of each earthquake on a world map. Do you see a pattern in the location of these earthquakes?

cont.

WHAT ABOUT EARTHQUAKES?

Is it likely that there will be an earthquake near your home? Explain why earthquakes only occur in specific areas of the world. Research to find out if there is a relationship between the location of earthquakes and the location of volcanoes. Explain your findings.

Date	Latitude	Longitude	Date	Latitude	Longitude
Jan 3 1968	51.8° N	173.3° W	July 5	7.0° S	147.3° E
Jan 3	17.1° N	99.5° W	July 7	41.8° S	171.9° E
Jan 7	33.5° N	141.6° E	June 21	7.4° S	155.1° E
Jan 10	13.8° N	120.6° E	June 27	46.3° N	7.0° E
Jan 13	31.2° S	68.4° W	July 3	34.7° N	75.1° E
May 28	56.2° N	158.0° W	July 4	36.9° N	28.6° E
May 29	62.3° N	149.1° W	July 14	20.9° S	68.8° W
May 29	3.1° N	83.7° W	July 18	8.9° N	93.9° E
May 30	15.8° S	167.6° E	June 27	8.2° S	119.7° E
June 2	41.2° N	143.4° E	July 6	58.7° S	24.9° W
June 3	36.0° N	141.2° E	July 18	9.6° N	40.2° W
June 8	87.0° N	51.3° E	July 26	22.4° S	12.6° W
June 9	39.0° N	46.0° E	June 29	20.6° S	66.2° E
June 11	41.5° S	85.4° W	June 29	19.9° S	33.6° E
June 12	24.9° N	91.9° E	July 6	1.3° S	33.3° E
June 12	13.8° N	120.7° E	July 31	80.0° N	6.3° E
May 31	36.1° N	31.0° W	Aug 4	40.8° S	43.3° E
June 1	24.7° N	121.9° E	Aug 4	53.0° S	9.6° E
June 5	36.1° N	66.2° E	Aug 6	26.7° N	44.5° W
June 8	87.0° N	50.0° E	July 21	16.9° S	172.2° W

EXTENSIONS

1. Investigate the Mohole project. What was the main purpose of the project? Was it successful?
2. Investigate the famous San Francisco earthquake of 1906. Also find information on the 1964 Alaska earthquake. Is California still subject to earthquakes? Explain why.
3. Scientists are attempting to predict the occurrence of earthquakes. How are they attempting to do this?
4. What is the Richter scale? How does it describe earthquakes?

REFERENCES/HINTS

1. Graves, William. "Earthquake." National Geographic, Vol. 126, No. 1, July 1964, p. 112.
2. Jackson, Joseph H. and Edward D. Evans. Spaceship Earth, Earth Science. Boston: Houghton Mifflin Co., 1973.
3. McDowell, Bart. "Earthquake in Guatemala." National Geographic, Vol. 149, No. 6, June 1976, p. 810.

Deep beneath the ocean's surface there are many remarkable things: huge mountain ranges, deep trenches, and unusual plants and animals. How do we get information about these wonders?

43

MATERIALS

Metric ruler and access to reference materials.

PROCEDURES

1. Go to your school library or IMC and research the term topography. What can you find relating to the topography of the ocean floor? How does it compare to the topography of dry land?
2. Find out some of the ways ocean topography is studied. See if you can find information on echo sounding. (Sonar and Hydrophone are words that might help you.)
3. Use the information you have gathered to draw a diagram of the ocean floor. Imagine that you are traveling across the ocean bottom. Begin where the land meets the sea. Be sure to include the following terms in your diagram: continental shelf, continental slope, ridge, basin, and trench.
4. Do the following activity to learn more about how the continental shelf was formed.
 - a. Find some open land near your school or home. Look for places where rainwater has run over the soil. Find a slope containing gullies about 5 cm wide.
 - b. With a ruler, measure the length, width, and depth of the gully before a rainstorm. Record your data.
 - c. After a rain, measure the length, width, and depth of the same gully. Record your data again.
5. What happened to the gully after the rain? Is it deeper? Wider? What happened to the materials that were carried away? Use your observations to explain how the continental shelf was formed.

DOWN TO THE DEPTHS

6. Find out about the exploration of Jacques Cousteau and others who have explored the ocean bottom. What kind of vehicles do they use for this exploration? What kinds of plant and animal life did they find? How have these plants and animals adapted to this special environment?

EXTENSIONS

1. Prepare a contour map of a section of the ocean bottom.
2. Research the topic of "canyons in the sea". Name some of the best known ocean canyons. How do you think these canyons were formed?

REFERENCES/HINTS

1. Andrews, Keith. Beneath the Oceans. New York: Grosset & Dunlap, 1973.
2. Engel, Leonard. The Sea. New York: Time-Life Books, 1969.

ARE WE BLOWING AWAY?

EARTH SCIENCE
GEOLOGY/GEOGRAPHY

EROSION
Observing, Inferring, Classifying

Have you ever felt that you were all worn out? Well, how do you think Mother Earth feels after centuries of wind and water erosion? You can easily make a device which will tell you how rapidly Mother Earth is wearing out in your area.

44

MATERIALS

2 rulers, crayon, double stick tape, scissors, small empty milk carton, and sand or soil.

PROCEDURES

1. Construct a wind erosion recorder. See figure to the right below. Begin by cutting two narrow slots on top of a small milk carton. Stick two rulers through the slots. Fill the carton with sand or soil to make it heavy. Cut two 30-centimeter strips of sticky tape. Put one strip evenly over the top of each ruler, **STICKY SIDE OUT**. Fasten the strip ends to each ruler with tape. Draw an arrow on the carton top with crayon.
2. Place your recorder where the wind is blowing loose soil. Point the arrow north. Leave the recorder in place for 30 minutes. Notice how windblown soil bits collect on the tape.
3. Look at the tape on all four sides and answer the following questions:
 - a. Which side has the most soil?
 - b. From which direction did the wind blow most?
4. Where do you think there is the most soil erosion around your school? Make more recorders. Place them in different areas around your school. What reasons can you give for what you find?
5. Collect windblown soil bits each day for a week. Change the tape each day. Arrange the tapes from least soil bits to most soil bits. Can you determine on what day there was the most wind erosion? Least erosion? Can you tell from which direction the wind blew each day?



ARE WE BLOWING AWAY?

EXTENSIONS

1. Use your recorder to determine the amount of soil erosion by wind in your neighborhood.
2. Contact the State Department of Natural Resources for more information on soil erosion. Find out what is being done to prevent erosion in your area.

REFERENCES/HINTS

1. Gega, Peter C. Science in Elementary Education. New York: John Wiley & Sons, p. 255, 1977.
2. White, Peter. "This Land is Ours--How Are We Using It?" National Geographic, July 1976, pp. 20-67.

WHAT'S COMING UP NEXT?

Did you know that the Hawaiian Islands are tops of huge volcanoes? What causes volcanoes? How often do they erupt? Let's see what you can find out about them.

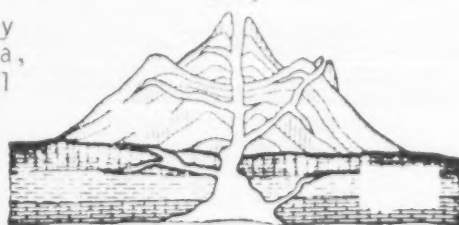
45

MATERIALS

Scissors, paper cup, plaster of paris, Bunsen burner, spoon, yarn, crayon, paper, and access to resource materials.

PROCEDURES

1. Construct a plaster of paris model of a volcano. Use the following procedure:
 - a. In a paper cup, mix plaster of paris and water. The mixture should be about as thick as a "thick" milk shake.
 - b. Break a crayon up into two or three pieces. Tie a 15 cm length of knitting yarn around each piece and push the pieces, one at a time, into the wet plaster. Be sure that each piece of crayon is completely surrounded by plaster and does not touch the sides or bottom of the cup. Let the ends of the yarn hang over the sides of the cup.
 - c. Let the plaster harden overnight. After it has hardened, cut the yarn off close to the surface of the plaster and tear away the cup.
 - d. Put the piece of plaster directly over an open flame. Leave it there until the crayon inside melts. What happens at the surface of the model? Explain why this happens. How does this process relate to the eruption of a volcano? In a volcano, where does the heat come from which melts the deeply buried rocks? What comes out of a volcano besides the melted rock? Explain how this can affect people and the environment.
2. Look up the following words in a dictionary if they are new to you: igneous rock, magma, sedimentary rock. Use these words to label a diagram like the one on the right:



WHAT'S COMING UP NEXT?

3. The chart on the right indicates the longitude and latitude of 39 volcanoes. Plot them on a world map. Do you see a pattern in location of these volcanoes? How can this be explained? Is a volcano likely to erupt near to where you live? Where would a new volcano be most likely to erupt?

Volcano	Latitude	Longitude	Volcano	Latitude	Longitude
Reventador	0 1° S	77 7° W	Krakatau	6 1° S	105 4° E
Ubinas	16 2° S	70 8° W	Barren I.	12 2° N	93 8° E
Maipo	34 1° S	69 9° W	Santorini	36 4° N	25 4° E
Mt. Burney	52 3° S	73 4° W	Vesuvius	40 8° N	14 4° E
São Jorge I.	38 6° N	28 0° W	Lanzarote I.	29 0° N	13 7° E
Katla	63 6° N	18 9° W	Paramushiro I.	50 3° N	155 3° E
Beerenberg	71 0° N	8 0° W	Katmai	58 3° N	155 0° W
Értá-Ale	13 6° N	40 6° E	Mt. Rainier	46 9° N	121 8° W
Niragongo	1 5° S	29 2° E	Lassen	40 5° N	121 3° W
Kartala	11 9° S	43 3° E	Tres Virgenes	27 5° N	112 7° W
Mauna Loa	19 5° N	155 9° W	Paricutin	19 5° N	102 1° W
Erebus	77 5° S	168 0° E	Poas	10 2° N	84 2° W
Pagan I.	18 1° N	145 8° E	Kanaga	51 9° N	177 2° W
Chyulu Hills	2 9° S	38 1° E	Brimstone I.	30 2° S	178 9° E
Saishuto I.	33 4° N	126 5° E	Late I.	18 8° S	174 6° W
Mayon, Luzon	13 3° N	123 7° E	Hunter I.	22 3° S	172 1° E
Makian	0 3° N	127 4° E	Tinakula	10 4° S	165 8° E
Lokon	1 4° N	124 8° E	Pago	5 6° S	150 6° E
Seroea	6 3° S	130 0° E	Fuji	35 4° N	138 2° E
Tambora	8 2° S	118 0° E			

EXTENSIONS

- Investigate the eruption of the volcano which covered Pompeii, a city in Italy, in 79 A.D. Also, investigate the Cerro Negro Volcano, which erupted in Nicaragua on November 16, 1968.
- Pretend you are watching a volcano erupt. Write a story to describe the sights and sounds. Use your imagination.

REFERENCES/HINTS

- Grove, Noel. "Vestmannaeyjar: Up From Ashes." National Geographic. Vol. 151, No. 5, May 1977, p. 690.
- Jackson, Joseph H. and Edward D. Evans. Spaceship Earth - Earth Science. Boston: Houghton Mifflin Co., 1973.
- Kraft, Maurice and Katia. Volcano. New York: Harry N. Abrams, Inc., 1975.
- Simpich, Frederick Jr. "Fountain of Fire in Hawaii." National Geographic. Vol. 117, No. 3, March 1960, p. 303.

ROUND AND ROUND THEY GO

How can you bring a mountain down to size? It's as easy as drawing a circle. As a matter of fact, that's just what you do when you make a contour map. Why don't you give it a try?

46

MATERIALS

A board approximately 15 cm x 20 cm, modeling clay, rulers, pins and paper.

PROCEDURES

1. On the board, shape the modeling clay into a formation resembling an island.
2. Looking down at the island, make a sketch of the outline (shoreline) of the island.
3. Next, place pins, horizontally into the model, at a height of 5 cm. To do this, vertically measure 5 cm up from the board's surface. Then line up a second ruler, horizontally, at the 5 cm marker, adjusting that ruler so that it touches the island formation. Place a pin at this point. Repeat this procedure until the formation is ringed by pins at approximately 5 cm intervals.
4. Make a sketch of the pins, putting it inside the first outline.
5. Repeat steps 3 and 4, at 10 cm, 15 cm, 20 cm, etc.
6. Label the lines on your final sketch according to their height. These lines now form a contour map of your island.

EXTENSIONS

1. Do some research on contour maps. Who invented them? Where can such a map be located?
2. Draw a contour map of the area in which you live; then construct a clay model which would correspond to the map.

REFERENCES/HINTS

1. Check with the City or County Surveyor, who may have a contour map of your area.

ROUND AND ROUND THEY GO!

2. See SAPA II Module #85, or an encyclopedia under the heading, "contour maps".
3. Check at your local state office building for quadrangle maps. They show the contours of the land.

Professional oceanographers spend hundreds of dollars for the water-sampling bottles they use. You can make one that will do almost as well--for only pennies.

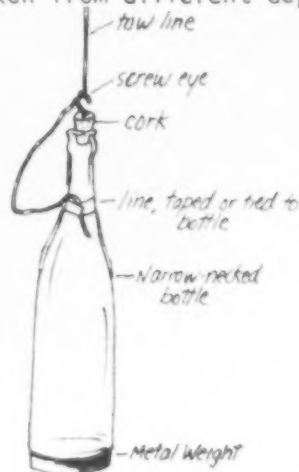
47

MATERIALS

Pop bottle, cork, screw eye, fishing line (or sturdy string), and waterproof glue.

PROCEDURES

1. Sample bottles are used to gather samples of water taken from different depths.
2. To make one: Fit the cork into the pop bottle. Attach a screw eye to the cork. Thread the fishing line, through the screw eye, and tie securely. Leave about 18 inches hanging free. This section of line should be taped or tied tightly to the neck of the bottle. Since the bottle will be filled with air, it will be too light to sink. You will need to attach some heavy metal or scrap to the bottom of the bottle. Use waterproof glue. See the diagram on the right to be sure that your bottle is assembled correctly.
3. To operate the bottle, mark off the fishing line by tying knots at one-meter intervals. This will help you to measure the depth of the water. Then lower the bottle to whatever depth you want. Then, quickly jerk on the line to pull out the cork. The bottle will fill with water, and the line will remain taped to the neck of the bottle. Carefully raise the bottle. Collect 8-10 samples of water from different locations. Label the bottles carefully with location, date, approximate depth of sample, and any other information that is useful.
4. Now test the water you collected. What is the temperature? What is the color? Salt content? There are even simple tests which you may find to check for chemicals in the water. What else could you check for?



AMATEUR OCEANOGRAPHER

EXTENSIONS

1. Make a table, showing the characteristics of water at various depths.
2. Write to the State Department of Health for more information on water testing and sampling.

REFERENCES/HINTS

1. A used wine bottle will have a cork that should work nicely.
2. Andrews, Keith. Beneath the Oceans. New York: Grosset & Dunlap, 1973.
3. Heirtzler, J.R. "Where the Earth Turns Inside Out." National Geographic, Vol. 147, No. 5, May 1975, p. 586.

What do you think would happen if all of the coal and oil in the world suddenly disappeared? Almost nothing would be the same. Everyday we rely on coal and oil for many things. Let's take a look at these two vital minerals.

48

MATERIALS

Access to reference materials.

PROCEDURES

1. You will be able to find lots of information on coal and oil; it's simply a matter of knowing where to look. Check out the references listed on this card. Also, try writing to a major oil company for information. Shell, Standard, or Mobil oil companies would be good places to start.
2. Find the answers to these questions:
 - a. Where are the largest deposits of oil found? Coal? Why were they formed in these particular areas?
 - b. How were these fuels formed? When were they formed? Why are they called fossil fuels?
 - c. How long does it take oil to form? Coal? What products can be made from oil? (You will be amazed at the number of products.)
3. On a map of the world, draw in the major coal and oil deposits. Can you make any generalizations about the locations of these deposits?
4. What about underwater deposits of oil and coal? How is oil extracted from underwater in the North Sea and waters off the coast of California? What hazards are brought about when accidents cause large amounts of oil to flow into the water? Explain.

EXTENSIONS

1. Oil and coal take a long time to form. Do you think we are using oil faster than it is being created? Will it ever run out? Look into the ecology aspects of oil and coal production and use, such as strip mining, oil spills, pollution, etc.

cont.

HIDDEN TREASURES

2. Can oil and coal be produced artificially? Explain.

REFERENCES/HINTS

1. Grove, Noel. "Oil: the Dwindling Treasure." National Geographic, Vol. 145, No. 6, June 1974, p. 792.
2. Mark, Herman F. Giant Molecules. New York Time-Life Books, 1966, p. 132-135.
3. Maurer, Charles E. "How They're Extracting Oil from Tar Sands." Popular Science, Vol. 210, No. 5, May 1977, p. 80.
4. Young, Gordon. "Will Coal be Tomorrow's Black Gold?" National Geographic, Vol. 148, No. 2, August 1975, p. 234.

THE SEAWE LIVE IN

EARTH SCIENCE
ATMOSPHERE/WEATHER

AIR PRESSURE
Formulating Models, Inferring, Predicting

You may not realize it, but you are carrying quite a burden on your back. But don't get worried--it's only air. We can't feel it, but the pressure of miles and miles of air is pushing down on us, and everything else, at all times.

49

MATERIALS

Glass tube (one meter long, 5-7 mm in diameter), liquid mercury, small dish, meter stick, and stand to hold glass tube. Caution: Mercury is poisonous, so be sure you handle it under the supervision of a teacher who has worked with it.

PROCEDURES

1. Make a simple barometer which will measure atmospheric pressure. Use the following procedure:
 - a. Carefully fill the glass tube with mercury.
 - b. With your thumb covering the open end of the tube, turn the tube upside down and place the open end in a dish of mercury. Use a ring stand to support the tube.
 - c. Use another stand to support a meter stick. Put it next to the tube of mercury. (Make sure the 0-end of the meter stick is just touching the top of the mercury in the dish.)
2. Answer the following questions:
 - a. What will happen to the level of mercury in the tube when the air pressure increases? When it decreases?
 - b. Do you think your barometer will be affected by changes in temperature as well as pressure? How can you find out?
 - c. What do you think would happen to the level of mercury in your barometer if you took it with you on an airplane flight? Explain why you think this would happen.
3. Using your barometer, measure the level of mercury in millimeters and centimeters each day for 2 weeks. Record your data in one column on a chart. In a parallel column record what the weather is like each day, (e.g., fair, cloudy, rain,

THE SEA WE LIVE IN

snow). Do you find that changes in the weather are related to changes in air pressure? Can you predict the weather by using only your barometer? How could you improve your predictions? Record your weather predictions each day for 2 weeks. Also record the predictions given by the weatherman. Who is more often right, you or the weatherman? Do your predictions improve with practice?

4. Find the answers to these questions:

- a. How are airplanes affected by the lower air pressure found at high altitudes?
- b. Why do most airplanes fly below 12,000 meters?
- c. Why is life above 6,000 meters difficult?
- d. Why is it impossible to burn a candle at 7,500 meters?

EXTENSIONS

1. Contact your local weather station to find out more about forecasting the weather.
2. Compare the mercury barometer to the aneroid barometer. Which barometer is more precise? More practical?
3. Find out how a siphon works. What role does air pressure play in making a siphon work?

REFERENCES/HINTS

1. Thurber, Walter A. and Robert E. Kilburn. Exploring Earth Science, The Atmosphere. Boston: Allyn & Bacon, Inc., 1976.
2. World Book Encyclopedia. Chicago: Field Enterprises Educational Corporation, Vol. 2 (Barometer, p. 83), 1977.

The "O" Zone. It almost sounds like a mysterious region deep in the ocean. But, actually, it is a layer of gas found high above the Earth's surface. What makes this ozone layer so important?

50

MATERIALS

Access to reference materials.

PROCEDURES

1. Find information on the ozone layer in encyclopedias or recent issues of magazines. (Note: Newsweek, Time, and Science News are excellent sources of information.)
2. Find the answers to these questions:
 - a. Where is the ozone layer located?
 - b. Why is the ozone layer important in the protection of man and his environment?
 - c. What are the major ways in which man is destroying the ozone layer? List these.
 - d. What would be the major effects on man if the ozone layer were eroded? On plants and animals?
 - e. Why are aerosol sprays containing fluorocarbons harmful to man and his environment?
 - f. What happens when ozone builds up in the lower regions of the Earth's atmosphere?
3. Find articles in the newspaper about ozone. What is meant by an ozone alert? Where do these alerts most often occur? What precautions should people take during an ozone alert?
4. If the ozone layer were completely eroded, list what you think would happen. Using your list and your imagination, write a science fiction story about life on Earth without the protective ozone layer. Let your imagination run!

THE "O" ZONE

EXTENSIONS

1. Investigate the crises caused by great build-ups of smog in large cities.
2. What is the actual chemical composition of ozone? Explain how its structure is related to the protection of the Earth's atmosphere.

REFERENCES/HINTS

1. Edelson, Ed. "The Great Ozone Debate." Popular Science, Vol. 210, No. 6, June 1977, p. 82.
2. Matthews, Samuel. "What's Happening to Our Climate?" National Geographic, November 1976, pp. 576-615.

The atmosphere extends for about 1500 miles above the Earth's surface. Many factors like pressure, quantity of oxygen and radiation vary depending on the distance from the Earth. Why not climb in your imaginary space ship and investigate some of the changes?

51

MATERIALS

Maps and reference materials about the atmosphere.

PROCEDURES

1. Become familiar with the words troposphere, stratosphere, mesosphere and thermosphere and identify their location in relation to the Earth's surface on a chart or diagram.
2. On a chart or diagram, relate altitude (in meters), atmospheric pressure (in atmospheres), and temperature (in Celsius degrees) to the various kinds of "spheres" listed in Procedure 1 above.
3. How do the jet stream, Van Allen belts, Aurora Borealis (Northern Lights), cosmic rays, and clouds of different kinds relate to the "spheres" listed in Procedure 1? What causes each of these?
4. How does the composition of the air change as you go upward through the "spheres" from the Earth's surface? How does this affect airplanes and space crafts?

EXTENSIONS

1. Investigate how the Earth's weather is affected by what goes on in the various "spheres".
2. What is meant by the "greenhouse effect" in relation to radiation received on the Earth's surface? How does this affect our daily lives?

REFERENCES/HINTS

1. Gore, Rick. "Sifting for Life in the Sands of Mars." National Geographic, Vol. 151, No. 1, January 1977.

WHAT'S UP THERE?

2. Mattheues, Samuel W. "What's Happening to Our Climate?" National Geographic, Vol. 150, No. 2, November 1976, p. 576.
3. World Book Encyclopedia. Chicago: Field Enterprises Educational Corporation, Vol. 1 (Air, p. 153), 1977.

TO SEED OR NOT TO SEED

The idea of modifying the weather to meet man's needs has long been a dream. Since 1946, this has become a possibility. But problems like, "Who makes the decisions of where it will rain?" still have to be solved.

52

MATERIALS

Access to reference materials.

PROCEDURES

1. Investigate progress on weather modification from 1946 to the present. Explain methods used to make rain.
2. Is it possible to produce rain over all areas of the Earth? Why or why not? Explain.
3. In modifying the weather, what problems can occur if rain falls on one crop-producing area but not on another due to man's modification? How does government regulation come into this situation?
4. Develop a chart for perfect distribution of rainfall for growing crops like (a) corn, (b) cotton, (c) soybeans, (d) tobacco over the world. Investigate the climates in which the crops grow, the water demands of the crops at various points in the growth cycle, etc. before making your chart.
5. Suppose that a "mad" scientist developed a technique to completely control the Earth's weather. Write a fiction story on what you think would happen. Be creative and imaginative.

REFERENCES/HINTS

1. Hartley, J.M. "Safer, Cheaper Rainmaking." Popular Science. Vol. 206, No. 4, April 1975, p. 81.
2. Roberts, Walter. "We're Doing Something About the Weather!" National Geographic, Vol. 141, No. 4, April 1972, p. 518.

Nature provides some of our most exciting displays of "fireworks" and sound. Have you ever wondered "what really happens" when you hear thunder and see lightning? Investigate the topics below to find some answers.

53

MATERIALS

Access to reference materials and maps.

PROCEDURES

1. Ask yourself, "What causes a thunderstorm on a warm day?" Investigate to find the explanation.
2. How is the "noise" of thunder produced? Is the amount of "noise" related to the amount of rain produced?
3. Lightning often accompanies a thunderstorm. What causes lightning? Investigate the dangers and safety measures people can take from lightning during a thunderstorm. Are there any good things about lightning? Explain.
4. What is meant by "high" and "low" air pressure? How are they related to thunder and lightning? What kinds of clouds are usually present during thunder and lightning?
5. How is energy involved in thunder and lightning during a storm? Explain.
6. Explain how jet aircraft and buildings are affected by lightning.
7. How is hail produced?

EXTENSIONS

1. Investigate how hurricanes, tornadoes and cyclones occur. Make a map of where hurricanes are most likely to happen in the world. Explain why. Make a similar map for tornadoes.
2. How do snowstorms relate to thunderstorms? Explain.

FLASH AND BANG!

REFERENCES/HINTS

1. Consult books on weather, storms, etc. for more information.
2. Contact your nearest U.S. Weather Bureau Office for more information on thunder and lightning.
3. Thompson, Philip and Robert O'Brien. Weather. New York: Time-Life Books, 1968.

ON A CLEAR NIGHT YOU CAN SEE FOREVER

There are few things in the world as interesting and remarkable as the sky on a clear and cloudless night. You can enjoy it even more by constructing the simple telescope described below.

54

MATERIALS

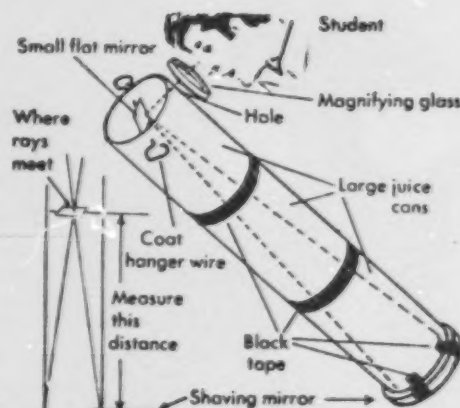
Curved shaving mirror, meter stick, 3 large juice cans with ends removed, piece of coat hanger wire, 2 cm square piece of flat mirror, magnifying glass, paper, tape, and access to reference materials.

PROCEDURES

1. In your IMC or library, investigate the discoveries of Galileo. What new information did Galileo gain using his telescope?
2. Find information on the two types of telescopes: reflecting and refracting. Answer the following questions:
 - a. What is the function of the ocular in a refracting telescope?
 - b. When you look at an object through the refracting telescope, does the image appear right side up or upside down? Explain.
 - c. How is the reflecting telescope different from the refracting telescope?
 - d. How is the Cassegrainian-type reflecting telescope different from the Newtonian-type reflecting telescope?
3. Follow this procedure to make a simple reflecting telescope:
 - a. First, measure the focal length of the curved shaving mirror. To do this you must measure the distance from the mirror to where the reflected sun's rays focus on a piece of paper. Record the focal length.
 - b. Tape the three large juice cans together. (Make sure the ends have been removed.) See diagram on reverse side of card.

ON A CLEAR NIGHT YOU CAN SEE FOREVER

- c. Tape the mirror to one end of the juice cans, as shown in the diagram.
- d. Mark the point on the cans which is 7 cm shorter than the focal length of the mirror. Attach a piece of coat hanger wire between opposite sides of the cans at this point. Tape a 2 cm square piece of flat mirror to this wire. Turn the mirror so that light is reflected out a 2 cm diameter hole cut in the can at this point.
- e. Use a good magnifying lens and look into the 2 cm hole. Focus your telescope on a distant building or object. Note: If you have problems in constructing your telescope, ask a high school science teacher for help.



EXTENSIONS

1. Go to your library or IMC and find information on radio telescopes. What advantages does the radio telescope have over the optical telescopes you just studied?
2. Research the contributions Bernhard Schmidt made to telescopes.
3. Locate information on Mount Palomar Observatory in California and Yerkes Observatory in Williams Bay, Wisconsin. What contributions have their telescopes made to man's knowledge of the heavens?

REFERENCES/HINTS

1. Disney's Wonderful World of Knowledge. The Danbury Press, Vol. 3, 1973.
2. Thurber, Walter A. and Robert E. Kilburn. Exploring Earth Science Astronomy. Boston: Allyn and Bacon, Inc., 1976.

Even though the planets and stars are millions of miles away, scientists are able to find out what they are made of by using a remarkable device called the spectroscope. You can make a simple spectroscope by following the instructions below.

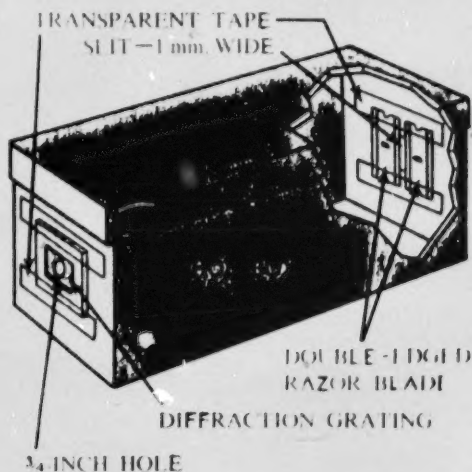
55

MATERIALS

Shoe box, replica diffraction grating, two double-edged razor blades, tape, metric ruler, and a lightbulb. Caution: Handle the razor blades carefully.

PROCEDURES

1. Look up the words prism and spectrum in a dictionary if these words are new to you.
2. Use the following procedure to construct your spectroscope:
 - a. Cut a slot about 1.25 cm x 2.5 cm in one end of a shoe box. Tape the razor blades over the hole so that the edges of the razor blades form a slit about 1 millimeter wide.
 - b. Cut a hole about 2.5 cm in diameter in the other end of the box. Tape a piece of grating over the hole. Be sure the lines of grating are parallel to the slit formed by the razor blades. See diagram below:



MYSTERY OF THE WHITE LIGHT

3. Use your spectroscope to look at the spectrum of a lightbulb. Point the end of the box with the slit toward the bulb. Observe the spectrum by looking through the diffraction grating toward the slit at the opposite end of the box. Can you see all the colors of the rainbow (red, orange, yellow, green, blue, indigo, violet) in the spectrum of the lightbulb? Were any of the lines brighter than any others? Record your data in a notebook.

EXTENSIONS

1. Research the "Doppler Effect". How is this concept related to light and its spectrum?
2. Use your spectroscope to view a fluorescent, neon or mercury-vapor lamp. Record your observations and give a short report to the class.
3. Investigate the relationship between color and wave length. Make a chart to show these relationships.

REFERENCES/HINTS

1. Ask a Junior or Senior High School science teacher to help you locate the diffraction grating.
2. Brown, Walter R. and Norman Anderson. Earth Science: A Search for Understanding. Philadelphia: J.B. Lippincott, 1973.
3. Moore, Patrick. The Picture History of Astronomy. New York: Grosset & Dunlap, 1972.
4. Mueller, Conrad G. and Mae Rudolph. Light and Vision. New York: Time-Life Books, 1969.

THE SWING OF THE PENDULUM

Have you ever wondered how the early scientists learned that the Earth rotates on its axis? They performed a simple experiment which is easy for you to do.

56

MATERIALS

A ring stand or other support, string, a weight (several metal washers will work), and a rotating stool.

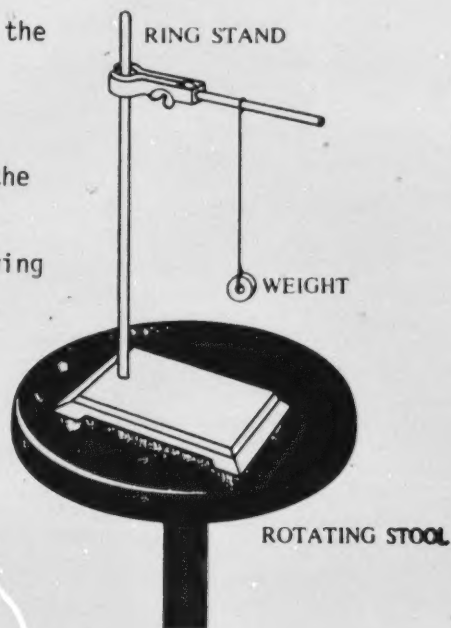
PROCEDURES

1. Use the following procedure to study the motion of the pendulum.

- Hang the weight from the ring stand as shown in the diagram:
- Place the ring stand on the stool and start the pendulum in motion. Be sure to note the direction of the pendulum's swing.
- Slowly rotate the stool supporting the ring stand and pendulum. Observe the motion of the pendulum.

2. After completing the activity, answer the following questions:

- How would you describe the motion of the pendulum in relation to the turning stool?
- Why do you think the pendulum swings in this manner?
- Does the motion of the pendulum on the rotating stool prove that the Earth rotates? Explain your answer.



Note: If you have problems getting the pendulum to work, ask a high school or college physics teacher for help.

THE SWING OF THE PENDULUM

EXTENSIONS

1. Find out if there is a large Foucault pendulum in a museum near your home where you could go and observe the motion of the pendulum.
2. Go to your IMC or library and find out how the pendulum has aided scientists in determining the shape of the Earth.

REFERENCES/HINTS

1. Brown, Walter R. and Normal Anderson. Earth Science: A Search for Understanding. Philadelphia: J.B. Lippincott, 1973.
2. Moore, Patrick. The Picture History of Astronomy. New York: Grosset & Dunlap, 1972.

How could man communicate with beings from outer space? Well, it would be difficult to send them letters or call them on the telephone, but perhaps we could "talk" to them by using a device called a radio telescope. Let's find out more about it.

57

MATERIALS

Access to reference materials.

PROCEDURES

1. Investigate how a radio telescope operates. What would be some advantages of the radio telescope over the optical telescope? What would be some of the limitations of the radio telescope? Why is the "focus" so important to the operation of a radio telescope? What shape would you make your reflector? Why?
2. Explain how radio telescopes can be used as "thermometers". What important discoveries have been made with these "thermometers"? Explain how radio telescopes operate as powerful radar devices. What kinds of things could the radar device "feel" on an object in space?
3. Investigate the two different types of radio waves which are received by the radio telescope (thermal radiations and nonthermal radiations). Why do only certain waves reach the Earth's surface? (Hint: What would happen if they were too short? Too long?)
4. Research and compare the Mill's cross-radio telescope near Sydney, Australia to the dish-shaped radio telescope near Arecibo, Puerto Rico. Which type do you think is best? Why?
5. Write a fiction story about communicating with intelligent creatures in outer space. Use your imagination.

EXTENSIONS

1. Find out more about radio telescopes by investigating the telescope at Sugar Grove, West Virginia.
2. Investigate the early discoveries in radio astronomy made by K.G. Jansky of the Bell Telephone Laboratories.

COMMUNICATING WITH OUTER SPACE

REFERENCES/HINTS

1. Bergamini, David. The Universe. New York: Time-Life Books, 1969.
2. Moore, Patrick. The Picture History of Astronomy. New York: Grosset & Dunlap, 1972.
3. Student Encyclopedia. Chicago: Rand McNally & Company, 1972.

From the earliest times, man has observed the sun, moon, stars and other heavenly bodies. Since they were visible to everybody at all times, they became the clocks and calendars to regulate man's activities such as planting and harvesting crops and charting courses for traveling. Learn how ancient man observed the sky and how modern man can still be fascinated by it.

58

MATERIALS

Access to reference materials.

PROCEDURES

1. Investigate the history of man's study of heavenly bodies and the contributions of different individuals and groups. Make a chronological chart (starting with the earliest individuals or groups) and indicate the major contributions of each. Be sure to include the following: Galileo, DaVinci, Copernicus, Kepler, Tycho Brahe, the Greeks, Romans, Druids, Chinese, Mayans and Egyptians.
2. On an outline map of the world, indicate the location of each of the individuals or groups on your chart from Procedure 1. Explain why you think each of these individuals or groups worked in astronomy in that geographical location in that particular historical period.
3. See if you can explain the relationship of mathematics to astronomy.
4. What instruments, tools, buildings, etc. did each of the individuals or groups on your chart in Procedure 1 use to observe the heavenly bodies? Explain.
5. Ancient people believed that heavenly bodies had some particular powers to influence their lives. Investigate how and why they oriented statues to gods whom they believed affected certain aspects of their lives. These included a rain god, sun god, wind god, fertility god. What kind of sacrifices did groups like the Mayans and Egyptians make to these gods?

EXTENSIONS

1. Select a group like the Mayans, Druids or Egyptians and investigate their contributions to ancient astronomy. Each of these groups left extensive ruins that we can visit today so we know many things about their work. Yet, some mystery remains. Write a story about the group you selected. Include diagrams and/or pictures of some facets of their work. Include why you think their civilization disappeared.

SKY STUDY

2. One of the instruments ancient peoples invented to utilize the knowledge they gained from the sun and its changing position in the heavens is the sundial. Make a diagram of a sundial and explain how it works. Make a sundial. How accurate is it?

REFERENCES/HINTS

1. Friedman, Herbert. The Amazing Universe. Washington D.C.: National Geographic Society, 1975.
2. LaFay, Howard. "The Maya, Children of Time." National Geographic, Vol. 148, No. 6, December 1975, p. 729-799.
3. Moore, Patrick. The Picture History of Astronomy. New York: Grosset & Dunlap, 1972.
4. Norman, James. "Mexico's People of Myth and Magic." National Geographic, Vol. 151, No. 6, June 1977, p. 832.

A fish in the sky? A lion in the heavens? Not really, but the stars in the sky appear to be arranged in unusual patterns called constellations. They have been named after bears or people or ancient gods and goddesses. With a little practice you can learn to locate these interesting patterns.

59

MATERIALS

Access to reference materials, a sky map or series of sky maps which show the positions of stars throughout the year.

PROCEDURES

1. Locate information on the observations of star groups made by people during ancient times. What relationship did people observe between these star groups or constellations and the sun throughout a year? Explain how the motion of the constellations served as a calendar during ancient times.
2. Obtain a sky map or a series of sky maps which show the positions of the constellations throughout a year. What do you notice about the change in position of the constellations from season to season? Why does this happen? What determines which groups of constellations you can see on a clear night?
3. On a clear night, try to locate the constellations, Big Dipper (Ursa Major) and Cassiopeia, in the northern sky. Which one seems to be on the top? Look at them again two hours later. How have their positions changed? Observe the two constellations at the same time for several weeks or months. Record your observations. While making your observations also locate Orion and Ursa Minor (The Little Dipper).
4. Do you know how to locate Polaris (North Star) by using the Big Dipper constellation as a guide? What constellation is Polaris a part of? What is special about Polaris that enabled sailors to use it in navigation?
5. On your star chart locate the 12 constellations of the zodiac. What is meant by the term zodiac? Why is this term appropriate? See if you can find information on the naming of these 12 constellations. Draw some of these constellations and write a short report on the naming of each one.

IT'S IN THE STARS

EXTENSIONS

1. Take a trip to a Planetarium if there is one near your home.
2. Investigate the names and meaning the Egyptians, Greeks and Romans gave to the constellations and how they influenced their religions.
3. What's the difference between astronomy and astrology? How are the constellations of the zodiac used in astrology?

REFERENCES/HINTS

1. Bergamini, David. The Universe. New York: Time-Life Books, 1969.
2. Jackson, Joseph H. and Edward D. Evans. Spaceship Earth, Earth Science. Boston: Houghton Mifflin Co., 1973.
3. Moore, Partick. The Picture History of Astronomy. New York: Grosset & Dunlap, 1972.
4. Friedman, Herbert. "The Family of Stars" in The Amazing Universe. Washington, D. C.: The National Geographic Society, 1975.

To return to the Earth, a spacecraft must re-enter the Earth's atmosphere. How does this affect the speed of the spacecraft? What happens to the spacecraft's temperature during re-entry? A simple experiment can show how a spacecraft is protected as it re-enters the Earth's atmosphere.

60

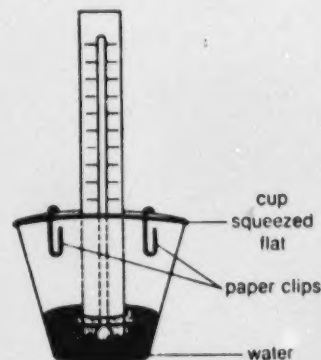
MATERIALS

Thermometer, small paper cup, water, paper clips, and access to a freezer.

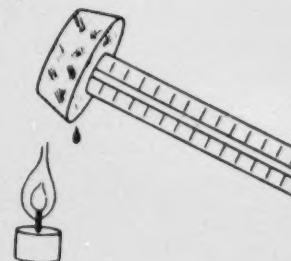
PROCEDURES

1. Place a thermometer in a paper cup. Add enough water to cover the bulb of the thermometer.

2. Squeeze the top of the cup and attach paper clips to hold it flat. See diagram on the right:



3. Place the cup in a freezer. When the water has turned to ice, remove the cup from the freezer and tear away the cup. Record the temperature reading of the thermometer. Hold the thermometer over a flame as shown in the diagram on the right:



4. Read the thermometer as the ice melts. NOTE: Do not let the flame hit the thermometer. Do not let the water put out the flame.
5. After completing the experiment, answer these questions:

"SPLASHDOWN"

- a. What was the initial temperature reading of the thermometer? Did the temperature rise while the ice was melting?
 - b. What do the thermometer, the ice cube, and the flame represent in this activity in relation to the protective shield in a spacecraft?
 - c. What happened to the heat from the flame?
6. Go to your library or IMC to find out more about the heat shield that protects spacecrafts. What is the heat shield made of? What is in the atmosphere that causes the spacecraft to heat up so rapidly? Why is it necessary for the spacecraft to meet the pressure of the Earth's atmosphere at a certain angle? Think--what would happen if the angle were too shallow? If the angle were too steep? Explain.

EXTENSIONS

1. Investigate the protective spacesuits worn by astronauts.
2. Find out more about the special parachutes called drogues which are released during "Splashdown".

REFERENCES/HINTS

1. Candy, Thomas. "Handclasp in Space." National Geographic, Vol. 149, No. 2, February 1976, p. 183.
2. Shelton, William R. Man's Conquest of Space. Washington D.C.: National Geographic Society, 1975.
3. Student Encyclopedia. Rand McNally & Co., Chicago, 1972.

When Neil Armstrong made the "small step for man" upon the moon's surface, he achieved a dream which people have held for centuries. Why did man begin a space exploration program? What failures did man encounter on the way to the moon? What is the next step. . . . ?

61

MATERIALS

Access to reference materials.

PROCEDURES

1. Investigate the main events which caused President Kennedy to accept the National Aeronautics and Space Administration's proposal to attempt to land men on the moon. What were the main objectives behind the first U.S. manned space program? To what extent have these objectives been accomplished?
2. Make a chronological chart of the major objectives and accomplishments of Project Mercury, the Gemini Program, and the Apollo Program. Be sure to indicate the following: the first suborbital flight of Alan B. Shepard Jr., the first manned orbital flight of John H. Glenn Jr., the first docking of two vehicles in space, the first lunar orbit mission, and the first manned lunar landing mission.
3. When man decided to land on the moon, he realized that extensive research and developments in science and technology would be necessary. Make a list of different areas that needed to be researched and different developments which were necessary before man could land on the moon. (For example, new materials were developed to function in the extreme cold and the extreme low pressures of outer space.) In what ways have the developments in science and technology which were required for the space program been transferred to other areas of our industrial society? Investigate the contributions made by the unmanned scientific programs to the manned lunar landing project, (e.g., Ranger, Lunar Orbiter and Surveyor programs). What did scientists learn about lunar soil from the unmanned Surveyor spacecraft?
4. Investigate the role of animals, especially the monkey, in the early stages of the space program. When did the first astronaut enter space? Find information on the contributions of Alan B. Shepard Jr., John H. Glenn Jr., Walter M. Schirra Jr., Frank Borman, and Neil A. Armstrong. How were the astronauts prepared for flight? How did three astronauts lose their lives on January 27, 1967? What was the cause of the tragedy? Following the accident, what major modifications were made in the Apollo spacecraft?

SECRETS OF SPACE

5. Compare the spacecrafts used in the Mercury, Gemini and Apollo programs. Investigate the following units which make up the Apollo system: spacecraft-lunar module adapter, the service module, the command module, and the launch escape system. Make a diagram of the living accommodations for an Apollo crew.

EXTENSIONS

1. Investigate the development of the Space Shuttle. What advantages will the Space Shuttle have over present space vehicles? In what ways does the Space Shuttle combine the advantages of the airplane and spacecraft? What is its schedule of operation?
2. Find out the influence which the Space Program has had on the science of meteorology.

REFERENCES/HINTS

1. Disney's Wonderful World of Knowledge. The Danbury Press, Volume 9, 1973.
2. The Kennedy Space Center Story. Public Affairs Office. John F. Kennedy Space Center, NASA, Kennedy Space Center, FL, 1973.
3. Man on the Moon. Dallas, Texas: Galina, Inc., 1969.
4. Schmitt, Harrison H. "Exploring Taurus - Littrow." National Geographic, Vol. 144, No. 3, September 1973, p. 290.
5. Weaver, Kenneth F. "Have We Solved the Mysteries of the Moon?" National Geographic, Vol. 144, No. 3, September 1973, p. 309.

Here's a chance to build paper airplanes in school and not get into trouble! Actually, paper airplanes fly using many of the same principles as their much bigger brothers and sisters.

62

MATERIALS

Paper of all sizes and shapes and an open space indoors.

PROCEDURES

1. The goal of this activity is to encourage you to explore and experiment with the design of paper airplanes. There are many factors which you should consider.
2. Do you want your plane to fly long distances? To reach high altitudes? To stay in the air for long periods of time? To do tricks?
3. Suppose that you want your plane to fly the longest distance possible. Should the wings be long or short? Should it have flaps or rudders? What type of paper should you use? Try a variety of designs. If you find one that seems to work, make small adjustments (add flaps, cut slits, etc.) and continue to experiment until you have the best plane. You may find that long distance planes are designed much differently than high altitude or trick planes.
4. You may be able to find a good book about airplanes in your library. Remember that the principles of flight remain the same for any size plane. You may find some useful ideas.

EXTENSIONS

1. Sponsor a paper airplane-building contest in your school.
2. Investigate special planes that fly at very high altitudes (e.g., the U-2) and explain how they are designed.

REFERENCES/HINTS

1. Becker, Beril. Dreams and Realities of the Conquest of the Skies. New York: Atheneum, 1967.

PAPER AIRPLANES

2. Josephy, Alvin M. (ed.) The American Heritage History of Flight. American Heritage Publishing Co., Inc., 1962.
3. World Book Encyclopedia. Chicago: Field Enterprises Educational Corporation, Vol. 1 (Airplanes, p. 200), 1977.

We have a more accurate map of the planet Mars today than we had of the Earth 200 years ago, thanks to the unmanned satellites that took pictures and sampled the soil. The next step could be to send a man there. Find out about the hazards and surprises an explorer on Mars might meet.

63

MATERIALS

Access to reference materials.

PROCEDURES

1. Investigate the recent Viking Mission to Mars. What were the main objectives of this mission? To what extent were the objectives met? Use the questions below to guide your research of Viking's touchdown and discoveries on Mars.
 - a. Why do scientists believe life was more likely to exist billions of years ago on Mars rather than today?
 - b. How is the atmosphere which surrounds Mars different from the Earth's atmosphere? Does Mars have an ozone layer which protects the planet from the deadly ultraviolet rays of the sun?
 - c. Do you think it is possible for Earth's atmosphere to become like the atmosphere of Mars? Explain.
 - d. How does the temperature of Mars compare to that of the Earth?
 - e. Why is Mars referred to as the "Red Planet"?
2. Locate information on the great dust storms on Mars. Where do these storms usually start? How often do these storms occur? Where is Mars in relation to the Sun when these dust storms occur? Why do you think this is so? Is there water on Mars? If so, is it similar to the water here on Earth? How do scientists think this condition has changed over the past millions of years?
3. Compare the planets Earth, Mars and Venus in terms of size, location in the solar system, and physical characteristics. Make a chart to record your information. Also, make sketches to go with your chart.

MISSION TO MARS

4. Write a fictional story imagining you are a Martian. Describe the type of spacecraft you might use to explore Earth and try to find out if there is life on Earth. Make a diagram of your spacecraft.

EXTENSIONS

1. Investigate the rotation and revolution of Mars. Are day and night on Mars the same length as on Earth? How many days are in the Mars' year? Compare the seasons of Mars to our seasons here on Earth.
2. Investigate the goals and instruments of Voyager 1 and 2 launched in August, 1977.
3. For more information on the exploration of Mars you can write to:

NASA Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

REFERENCES/HINTS

1. Gore, Rick. "Sifting for Life in the Sands of Mars." National Geographic, Vol. 151, No. 1, January 1977, p. 9.
2. "Mars Album 6." Science News, Vol. 111, March 19, 1977, p. 186.
3. "Mars and Earth." NASA Facts, An Educational Publication of the National Aeronautics and Space Administration, NF-61/8-75.
4. Weaver, K.F. "Mariner 9 Journey to Mars." National Geographic, Vol. 143, No. 2, February 1973, p. 230-263.

With fast population growth the Earth may some day run out of space for people to live. Where will we turn then for places to produce food, run factories and build homes? Space colonies were once a wild dream but are now a real possibility. Maybe you can help decide how to get out there, who will go, and what activities are possible out in space.

64

MATERIALS

Access to reference materials and simple construction materials.

PROCEDURES

1. Locate information on the work of Gerald K. O'Neill, the man who first began investigating the possibility of space colonies. Why does O'Neill think space colonies are necessary? What will the colonies be made of? Where will these materials come from? According to O'Neill, what type of power would be used in the colonies? Describe the power stations which would be built. What problems would be eliminated by using this power? What are some other uses and advantages that could result from space colonies?
2. What would be the main problems connected with space colonies? How could they be corrected?
3. Describe the location of the orbit the first space colonies would probably take. How would gravity in a space colony be different than that on Earth? How would an elevator, for example, have to be adapted to this difference?
4. Write a fictional story about life in a space colony. You may want to consider the following items when writing your story: transportation, architecture, clothing, food, power, system of government, schools, kinds of games people could play, and climate.

EXTENSIONS

1. Develop a detailed drawing or three dimensional model (wood, styrofoam, cardboard, or other material) of a space colony. Include as many details as you can.

REFERENCES/HINTS

1. Achee, Bonnie. "Living in Space." Science Digest, April 1977, p. 8-12.

cont.

LIVING IN SPACE

2. Asimov, Isaac. "The Next Frontier?" National Geographic, Vol. 150, No. 1, July 1976, p. 76-90.

GENERAL

THEY'VE GOT RHYTHM

BIOLOGICAL CLOCKS
Experimenting

Life is filled with all sorts of remarkable rhythms: the beating of a heart, the blossoming of a flower, the migration of turtles and salmon. It's a fascinating field to explore.

65

MATERIALS

Access to reference materials, plant seeds (specified below) and a small plot of land.

PROCEDURES

1. Check to see how well your heart beat keeps time. Does it beat once a second? What would happen if you were running?
2. Find information in encyclopedias or books about the origins of our units of time (year, week, day, etc.). Do they relate to natural or biological events?
3. Find information about the migration of geese, the hibernation of bears, or the spawning of salmon. Nature has many ways of keeping time.
4. Try to make a biological clock of your own. It will be based on the opening and closing of certain blossoming plants. You'll need to experiment with different types of flowers, but here are some samples:

Plant Name			Time of Day
Spotted Cat's Ear	opens	at	6 a.m.
African Marigold	opens	at	7 a.m.
Mouse Ear Hawkweed	opens	at	8 a.m.
Prickly Sowthistle	closes	at	9 a.m.
Common Nipple-wort	closes	at	10 a.m.
Star of Bethlehem	opens	at	11 a.m.
Passion flower	opens	at	12 noon
Childing pink	closes	at	1 p.m.
Scarlet pimpernell	closes	at	2 p.m.
Hawkbit	closes	at	3 p.m.
Small bindweed	closes	at	4 p.m.
White water lily	closes	at	5 p.m.
Evening Promise	closes	at	6 p.m.

THEY'VE GOT RHYTHM

EXTENSIONS

1. Does man have an internal "clock"? Investigate the phenomena of "jet lag". In what other ways does man keep track of time?

REFERENCES/HINTS

1. Goudsmit, Samuel A. and Robert Claiborne. Time. New York: Time-Life Books, 1966.

Through the years, man has used many different ways to tell time. Some clocks were simple and easy to make, others were amazingly complicated. Let's take time to look at time.

66

MATERIALS

Access to reference materials.

PROCEDURES

1. First, go to a good encyclopedia and look up clocks. What is a sundial? What is a water clock? Hour glass? Candle clock? When were mechanized clocks first made? What is the difference between a spring clock and a pendulum clock? When were watches first made? What is an atomic clock?
2. Here's a simple way to make a sundial. Push a stick into the ground, so that it faces straight up. At 10 o'clock in the morning according to the school clock, make a mark on the ground corresponding to the shadow which the stick makes on the ground. Keep marking the ground at one-hour intervals. You now have a simple sundial. How accurate is it? Will it stay accurate? What would keep it from working?
3. In the military services, all through Europe, and in many other areas of the world, people use a different clock than we are used to seeing. Instead of having 12 hours, it has 24 hours. When the hour hand has completed one revolution, one day has gone by. Do you think this clock is a good idea? Why? Make a 24-hour clock and have your friends use it to tell time.

EXTENSIONS

1. You've heard of the metric system, but have you ever heard of the metric clock? There are only 10 "hours" in a day, but a metric hour is longer than a regular hour. How long would it be? At mid-day, what would the metric clock read? Make a metric clock and explain it to your friends.

REFERENCES/HINTS

1. Goudsmit, Samuel A. and Robert Claiborne. Time. New York: Time-Life Books, 1966.

This is a simple game, which is fun to play. It also teaches you something about the scientific method. When you find a game that is fun and teaches you science at the same time, then you've got something that's hard to beat.

67

MATERIALS

A deck of 52 regular playing cards and 3 or more players.

PROCEDURES

1. One of the players is selected as the rule-maker or judge (players can take turns being judge).
2. The judge secretly writes down a rule which will govern the play of the game. A typical rule might be:

"If a red card is on top, then a black card must be played. If a black card is on top, then a red card must be played."
3. The cards are then dealt to the players. If there are only a few players, you may wish to shorten the deck by removing all of the 2's, 3's, etc. Each player should be dealt about the same number of cards (between 7 and 12, depending on the number of players). All cards but one should be dealt and that card should be turned face-up to begin the starter pile.
4. Now play begins. The first player selects a card from his/her hand and shows it to the judge. If the card correctly fits the rule, then the judge allows the card to be placed face-up on top of the starter pile. If it does not fit, the judge shakes his/her head, and the card is returned to the player's hand. In either case it becomes the next player's turn.
5. Play continues until one of the players gets rid of all of his/her cards. This player then becomes judge for the next game. You will quickly realize that the player who first guesses the rule will probably be the winner.
6. The rule chosen for play is very important. It must be neither too simple, nor too difficult. Here are some sample rules:
 - a. If a club is on top then a diamond must be played, then a heart, then a spade, then a club, etc.

PATTERNS

- b. If a face card is on top, play a non-face card and vice-versa.
- c. Two red cards must be played, then two black cards, etc.
- d. Cards must be played in the following order: club, spade, diamond, heart, etc. In addition, an "8" may be played at any time.

EXTENSIONS

- 1. Keep a list of the rules which seem the best during play. These may be used again or new ones may be created.

REFERENCES/HINTS

- 1. Gardner, Martin. The 2nd Scientific American Book. New York: Simon and Schuster, 1961, p. 165.

Using only the simplest equipment, you can make a game-playing "robot" which actually "learns" as it plays. In fact, the robot learns so well, that you soon will not be able to beat it!

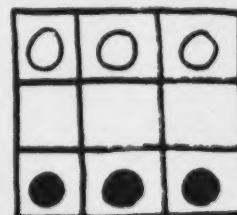
68

MATERIALS

24 empty matchboxes (match boxes work best, but match books will do), colored toothpicks.

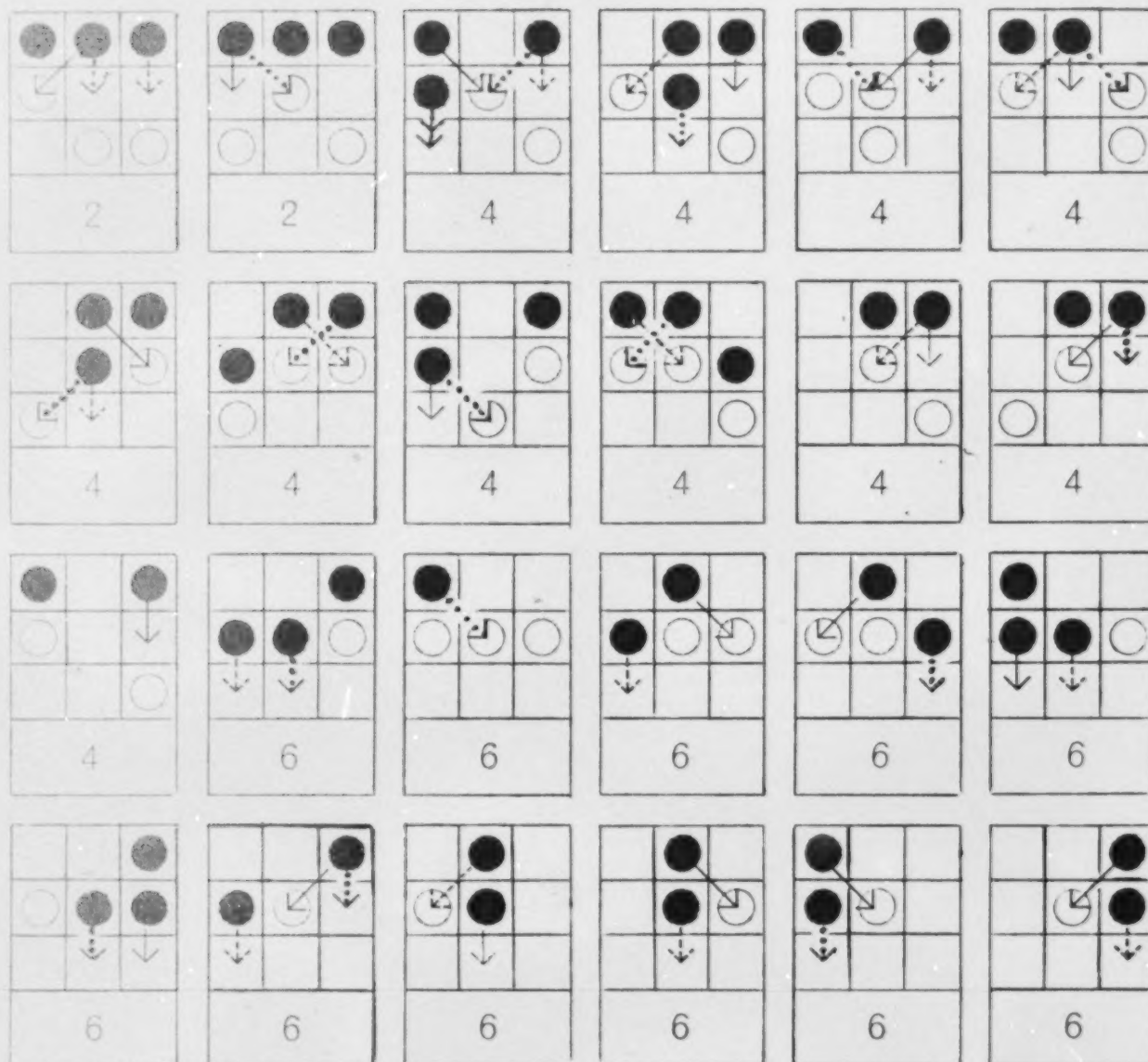
PROCEDURES

1. First, you must be introduced to the game which your robot will learn to play. It is a very simple game played on a 3 x 3 board (similar to a tic-tac-toe board) with three markers (men) on each side as shown in the diagram on the right:
Dimes and pennies work well as men.
2. Only two types of moves are allowed:
 - a. A man may move straight forward to an empty square.
 - b. A man may capture an enemy man by moving one square diagonally, left or right, to a square occupied by the enemy. The captured piece is removed from the board. Men may NOT move diagonally to an empty square and may NOT capture enemy men straight ahead. (Note: The moves are similar to the pawn moves in chess, but all other chess rules relating to pawns, such as promotion or double first move, are NOT permitted.)
3. A game is won in any of three ways:
 - a. By advancing a man into the third row (enemy's home position).
 - b. By capturing all enemy pieces.
 - c. By forcing a position in which the enemy cannot move.
4. Players alternate moves, moving one piece at a time.



BUILDING A ROBOT THAT LEARNS

5. Now you can construct the robot. First, make a copy of each of the 24 diagrams below:



Use colored pens or pencils, for the arrows. $\rightarrow$ is a blue arrow, $\dots\rightarrow$ is a green arrow, $---\rightarrow$ is a red arrow, and $\rightarrow$ is a yellow arrow. Then paste the copies onto the empty matchboxes.

6. Next, colored toothpicks are placed into the matchboxes; one colored toothpick corresponding to each colored arrow on the diagram outside. (You may wish to break the toothpicks into smaller segments.)
7. The human player always moves first. You have two choices, a center move, or a left side move. (Since a right side move would result in a position identical to the left side move, but "mirror-reflected", only the left side move is given. This cuts down on the number of matchboxes.)
8. Look at the matchbox numbered 2 (for second move) and find the position on the board. Hold the matchbox so that no toothpicks will escape, and shake it. Then let one toothpick escape from the box. The color of the toothpick will indicate the move that the robot will make (according to the colored arrows on the diagram). Make the move, then replace the toothpick.
9. It is now the human's turn to move. Play continues until the game is won by either side. The game will never last more than 6 moves. The matchboxes labeled 4 show all of the possible 4th moves for the robot. Boxes labeled 6 list all the possible 6th moves for the robot.
10. Now it is time to "program" the robot so that it will learn from its mistakes. If the robot loses a game, remove the colored toothpick corresponding to the last move made by the robot. Now, it will be unable to repeat its mistakes. If the robot wins, no changes should be made.
11. Soon, you will find, that the robot is a good student, and will be consistently beating its creator.

EXTENSIONS

1. Design a robot to play other simple games. Tic-Tac-Toe will be difficult, but you may enjoy the challenge.
2. See what you can find out about other machines that learn. Are there chess-playing robots?

REFERENCES/HINTS

1. Gardner, Martin. "Mathematical Games." Scientific American, Vol. 206, No. 3, March 1962, p. 138.

Have you ever heard of random numbers? If you think about it, random numbers are pretty strange creatures. What is random? What is a random number? How do we produce them?

69

MATERIALS

Access to reference materials.

PROCEDURES

1. How well do people produce random numbers? Draw a line 20 centimeters long on a piece of paper. Ask a friend to choose a point "at random" on the line. Then measure from the left end of the line to the chosen point. Record your result, rounding to the nearest centimeter. Repeat this procedure with as many people as you can.
2. Now look at the numbers you have collected. How many 1's, 2's, etc. do you find? If people truly chose the numbers at random, each number should appear about the same number of times. Do they? Are people good "generators" of random numbers?
3. Here's another way of collecting numbers which may prove to be random. Using an old telephone directory, write down the last four numbers of every second entry. Write down at least 200 consecutive numbers. Can you see any pattern in these numbers? (e.g., 1, 2, 4, 8, 16, 32) Does any digit appear too often or too seldom? Does the number represent anything (a code perhaps)? If a series of numbers "passes" several randomness tests, like the ones described above, then it is considered a random sample.
4. But consider this: Suppose you were unable to locate the pattern in a series of digits. It wouldn't be random, but you would think that it was. It is very difficult to determine if a series of numbers is really random. In fact, if a number sequence passes every known test for randomness, then it must be a very special set of digits. But how could a "special set of digits" ever be called random? It's a tough question to answer.

EXTENSIONS

1. Find other ways to make random number sequences, then test them for patterns. Are long sequences more likely to be more random than short sequences?

cont.

TAKE YOUR CHANCES

2. Locate a random number table. Do you know how to use it? How was it made?
3. Of what uses are random numbers? Why do we use them? See if you can find out where random numbers are used in your community.

REFERENCES/HINTS

1. You can find a random number table in the IMC or library, or ask the high school math teacher to help you find one.
2. Gardner, Martin. Mathematical Carnival. Alfred A. Knopf, New York, 1975, p. 161-172.

How good are you at guessing? Have you ever made a guess and then found out later that you were exactly right? Or way off? Here's a way to find out how good you are.

70

MATERIALS

Simple gram scale, weight set if necessary, and a wide variety of objects to be weighed.

PROCEDURES

1. Set up a chart for recording your information. Use three columns: estimation, actual measurement and percent error.
2. Select an object, estimate its weight and record it in the proper column.
3. Now, weigh the object and record the actual weight.
4. Next, calculate the percent of error between the real and estimated weights.

To do this, subtract the smaller number from the larger number to find the difference; then divide the difference by the actual weight. Multiply your answer by 100 and you have the percent error. If your guess was too high put a plus (+) in front of the number. If it was too low put a minus (-). (Example: estimation, 120 grams; actual weight, 150 grams. $150\text{g} - 120\text{g} = 30\text{g}$; $150\text{g} \div 30.00\text{g} = .20\text{g}$; $.20 \times 100 = 20\%$; -20%)

5. Repeat the procedure for a large number of objects.
6. Did you improve as an estimator? Were your guesses too high or too low? What was your average error for all the objects you estimated and measured? Were you more accurate with light or heavy objects? Would your guesses be accurate enough to use in an experiment?

EXTENSIONS

1. Repeat the experiment, but use length instead of weight.
2. What percent error is "acceptable" for a scientist?

GOOD GUESSING

REFERENCES/HINTS

1. An accurate scale might be obtained from a nearby Junior or Senior High School science department.
2. If you have trouble calculating the percent error, ask a Junior or Senior High School science or math teacher for help.